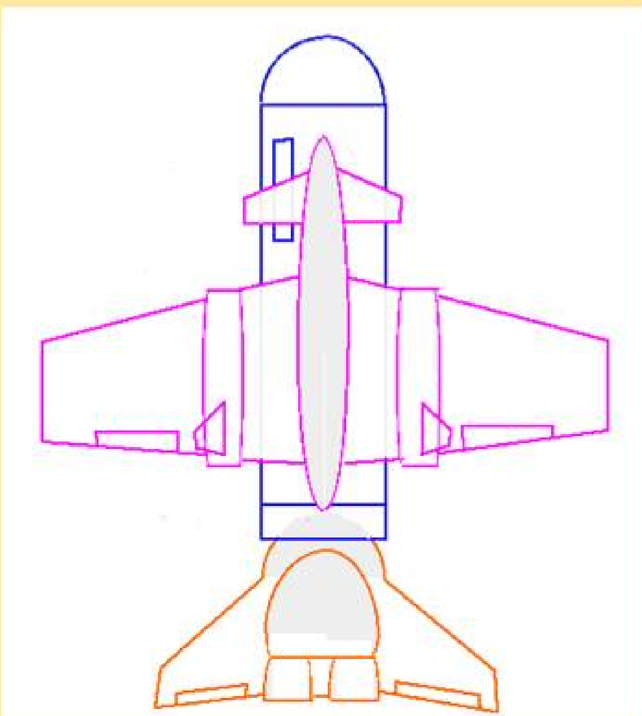
James E. D. Cline

Building Up

The Novelway Prototype Shop
Crisis On First KESTS
And the technical background of the concepts



Their corporate bosses have given them a dangerous job intended to fail - the building of the first small Space Elevator - but when they succeed at that task, they are transferred to another project, that of finishing building the first classical wheel-type Space Station in LEO - where they discover that it is a prison from where they are intended to never return.

Building Up is a science fiction novel in a series by Jim Cline about efforts to rejuvenate the planet by gaining high efficiency electrical lift access to high earth orbital space resources of constant solar energy, total recycling of toxic materials, high level rocket launch facilities, and plenty of room to live; all made possible by building various space access hoop structures electro-dynamically supported by kinetic energy expressing centrifugally stored within themselves, .

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Including the short stories
The Novelway Prototype Shop
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And the technical background of the story's concepts

Also in this saga series by J. E. D. Cline:
The Novelway Prototype Shop
Building Up
Crisis On First KESTS
The Ark Of 1984's Future
Spacetrains Are For Peacetime
It's Down To Earth
The Torus City Ice Shields Returning Home

Other science fiction by the author:
Masters of the Trading Game
Religion On Another Planet
Past The Town Prison

Also see the author's websites:
www.kestsgeo.com
www.escalatorhi.com

The author's major blog:
www.kestsgeojedc.blogspot.com

Related published technical papers by the author:

Cline, J. E. David, “Treehouse Haven”, Meditation Magazine, Winter 1990, 28-31
Cline, J. E. David “Wet Launch of Prefab Habitat Modules” Space Manufacturing 10, Pathways to the High Frontier, Space Studies Institute, AIAA, 1995, 88-91
Cline, James E. D. “Kinetically Strengthened Transportation Structures” Space 2000 Conference Proceedings, American Society of Civil Engineers, 2000, 396-402.
Cline, James E. D. “Kinetically Supported Bridge Vehicle Lift To GEO” Space 2002 Robotics 2002 Conference Proceedings, ASCE, 2002, 8-21.
Cline, James E. D. “Energy Flow in Kinetically Strengthened Transportation Structure Systems to Space” Earth & Space 2004 Conference Proceedings, ASCE, 2004, 859-866.
Cline, James E. D. “The Space Escalator Carousel's Unique Potentials” Space Exploration 2005 Conference Proceedings, SESI, 2005, 230-238
Cline, James E. D. “Characteristics of Space Escalator Carousels vs. Space Elevators” Space Exploration 2005 Conference Proceedings, SESI, 2005, 355-364

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Image of Cayambe Peak from Google Earth
Cover design by J. E. D. Cline
Interior formatting by J. E. D. Cline

Available soon in paperback form at Amazon.com

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This book is dedicated to my daughter Dia, whose New Mexico home provided respite midway during my long trips to space conferences during the early 2000's, where she and her husband Marc would also take the time to be pretend audiences for me while I was practicing giving my conference presentations of my technical papers, while I held up my viewgraphs or showed my PowerPoint presentations on my laptop computer, and ask thoughtful - and often tough - questions later; thus enabling me to more easily face the real space conference audiences.

Foreword

This science fiction novel, “Building Up,” was initially written in participation with the annual writing activity hosted by NanoWriMo each November; this one written in 2006.

It starts out with an adventure starting to build the first Space Elevator under difficult circumstances; the heros of the story get into significant detail of the doing of that, including the building of a small test version of a Solar Power Satellite, since the subjects were fresh in my mind from my writing of a technical paper “Long Range Transmission of Electromechanical Energy“ which is included as a reference in the back of this book.

The adventure drifts into the building of a version of the classical wheel-type Space Station in Low Earth Orbit, using the technique I had proposed for building prefab modules of the wheel, assembled and testing on the ground for livability and systems integration, then since each wheel segment was designed to be used as its own fuel tank during launch, each segment module is launched by chemical rocket for teleoperated docking into the mile diameter spoked wheel configuration in LEO, all put together before the first human arrives at the space station, making it a low-cost, risk-free construction process; of course, all such projects have difficulties and politics involved and an example plays out in the story.

Then the adventure moves into the building of the first KESTS, Kinetic Energy Supported Transportation Structure, between ground and Geostationary Earth Orbit, with its own set of challenges.

Before the novel itself, a short story is included as a prologue. Part of my first effort in participation with the NanoWriMo.org annual novel writing event, produced an adventure involving technologies leading up to those used in this novel, titled “The NovelWay Prototype Shop,” which sets the stage for “Building Up.”

After the end of “Building Up,” a short story written just for the experience of translating one of my own life adventures into a sci fi fantasy story adventure, “Crisis On First KESTS,” which on a timeline would follow “Building Up.”

This book then continues with the substance of some of the technical papers previously written by the author, that provided inspiration for the adventurous contents of this science fiction novel. Perhaps some readers might find them of interest, perhaps even use in their own aspirations.

And finally, the author would like to recommend the writing of sci fi in the area of one's interests or expertise, particularly in participation with the annual November NanoWriMo.org's online activity. It provided an outlet for the frustrations of the author regarding getting his technical projects accepted and going in the corporate and academic world, as well as his frustrations in not being able to attract a loving woman as partner; so the writing of these sci fi stories has provided a way of living out those dreams. It is somewhat better than having nothing.

Jim Cline, Ephrata, WA, 2009

Prologue

The Novelway Prototype Shop
A sci fi short story by Jim Cline

Background: Novelway Prototype Shop - introduced the concepts of the ground commute system called "PullBand Ground Commute System", a concept I had begun in the early 1970's while waiting in the long gas rationing lines, including my early effort, in the early 1980's, at writing re need for efficient commute to prevent CO_2 buildup.

This short story begins by using story content from one I had started in the 1980's just before the sudden end of the petrochemical supply-stressful Iran-Iraq war; that writing was my only remaining item which I had written about the PullBand Commute concept, still in my possession after the initial burglary of my files at my residence. The file, on my Adam Coleco computer, having survived the intellectual property burglaries no doubt due to its beginnings telling of redwood trees; was titled “Unfinished Transportation Story” for a long time after that, for lack of a better title. It inspired the author's first effort at participation in a NanoWriMo.org writing event, and was later incorporated into the first part of that novel's effort, since it was better than what was written at the first start of the NanoWriMo.org's first writing; it was expanded upon to become this early effort short story, after the end of the 2004 NanoWrimo.org activity was over.

It may not be apparent at first, but this story basically sets the stage for the rest of the saga.

The Novelway Prototype Shop

Redwood Forests Remembering

The great redwood forests had memory of their past eons of greatness, and the mind of their collective beingness came to a decision: it is time to have the change. Their aura was so expansive that it had felt the entire planet's saga, now written into their essence.

And that aura felt how now the carbon-stored sunshine energy, so patiently and laboriously stashed away by countless plant beings ages ago, so as to enable an oxygen-based animal life to exist, was being poured back into the atmosphere faster than sea and land photosynthesis beings can re-absorb it. What was causing this? They felt deeper into it, seeking.

It was these new two-legged scrappy beings with their machines, who, like a mosquito on a bird's back, stuck a probe deep into the earth's mantle and drew up the fluid petrochemicals, then burned them back into the atmosphere, heedlessly. It was not for the carbon to build their clever machines out of; no, it was to pull out the stored past energy of the sun that was consumed to stash the carbon away from the atmosphere, so long ago, that life might wonderfully expand and prosper, based on oxidation power.

So the great redwood beings coalesced into their planetwide aura, a new pattern of thought channels for those scrappy knowledge-gathering beings and their machines so clever. Like the river channels, new thoughts would flow as time went on, engraving new

patterns for their civilization which now squatted so heavily on the world of nature's vast life flow.

The misty morning fresh dawn cooly sifted down through the great redwood tree, its top so high the Pacific Ocean was in view, multitubular cluster strong long trunk, down to where its roots fingered along in the soil below it, tasting the moist chemistry for the building pieces for today's construction. The great tree sipped of the earth's dainty water and aired her limbs in a fresh breeze, then focused on the interesting pair of beings who had chosen to nestle between her roots and great branches overnight. The couple were snuggled peacefully in each others' arms, knowing in their dreams of the warmly loving dance of life, down there in their tent so tiny, a cold campfire nearby, and a metal car machine. The redwood tree resonated with that peaceful togetherness intertwined in love so quietly gentle resting, resonated like she had always resonated with all her spread family across the great land across time in oneness, spreading bole to bole, bonded family united in auric oneness knowing of beingness so detailed. She spread her part of the forest aura around to tuck in the loving couple a bit more, and waited with the patience of eternity for new things to happen. Yet this pair of cuddly beings, in the tent sandwiched between her awning branches and anchoring root field, were of the kind that had brought forth the metal machines that crawled around releasing the CO_2's carbon, so as to utilize the energy of the sun that so long before had been stored so as to lock the excess carbon away from the air. And the metal machine they had brought, was it not one of them? Yes. So the redwood tree gently laid upon the dreamy couple, a holographic piece of the new auric pattern which the great forest had formed. The new auric pattern so softly and gently merged with that of the two sleeping beings, now one with them.

Camping Aromas of Fresh Coffee

Aromas of fresh coffee and fried pancakes which Marsha was cooking on re-kindled campfire, wafted in along with cool breeze through the open tent flap, to awaken John to the day. What he been dreaming? Something about the car and air and trees, what was it? Like they were all dancing together with the people a new song; strange dream.

Marsha, too, admired the aroma and flavor of the fresh coffee, and as her eyes drank in the wondrous foliage of the forest around them, and especially the curiously interesting redwood tree over their head, its branches like a mother hen over her brood of chicks, protecting and comforting in instinctual responsibility.

Marsha sipped coffee more, noticing John was stirring in the tent. What was it about these nights with him, how the next day her usual no-nonsense, get it done right, avoid the unconventional, attitude changed to add a curiosity of "what would happen if...." John was certainly low-maintenance, all she had to do was be there for him; he seemed totally addicted to her. Yet a man of dreams was he, always off in the future, could hardly take care of himself in the real tough world. Why did he let people walk all over him, make him such a fool? No dummy, him. It was times like this morning that she actually considered taking the position at her Dad's prototype shop, be lead engineer in the R & D section that normally scared her with its demands to create things college never taught her to do. Intimacy with John somehow opened up some new part of herself so that the unconventional became an interesting adventure to make happen; there would be a way, and it would be fun. Instead of the usual irritation at the very thought of having to do something not by the book, what are those idiots going to ask for her to make

happen next. She had done well in college, would go back for her masters degree in a few years; she knew every engineering principle that school could teach, and applied it well at her job, no question.

John wafted out of the tent along the path of the coffee aroma, receiving a cup of brew from her. These times with her brought a joy of belief that dreams will come true, the world is here to make them happen, when she was around him. And there was a new magic in the air here somehow, more than the usual forest fine air. Life is wonderful, keenly alive, when he was with her; all would turn out OK, he knew with certainty, like now.

Campers, Meet Forest

Yet, the nagging thought that tomorrow he would be back at his job at her Dad's prototype shop, wiring up one-of-a-kind gizmos per others' direction, a Nobody. On the production line he struggled to keep up with the regular techs; but in the R&D shop he imaginatively found practical solutions to make the unconventional into working reality.

And the redwood tree, something was unconventional about it, he felt. Looking intently at its bark and branches, it looked like any other one. He puzzled over it a bit more, then plunged into the stack of hotcakes Marsha handed him, complete with fried egg atop and syrup poured all over it, ah, delicious cook she was, so fine.

There were few words shared between them. Few were needed with John. That was odd, she suddenly realized; all the other men - and she had known a lot of men - were a steady stream of talk of how great he was, how great she was, telling her what to do. But this

man, it was OK just to be around him while they got things done. "More pancakes please" her mind filled in as he silently handed her the emptied plate and headed out to bring more wood for the fire. Yes, she smiled to herself, this one was very special to be around, indeed. And this forest place was too, here and now with John; she knew now that wonders were hers to make happen.

Gas Rationing

John and Marsha shared a few moments over coffee during breaktime at her Dad’s shop, NovelWay Prototypes, Inc; commenting that here it was 1974 and no indication of petroleum wells going dry yet, but they were already having to wait in long gas lines at the gas station, gas being rationed due to oil blockades overseas. Would it never end, already three months and the international conflicts were increasing. People could do so much more if they would cooperate fully instead of wasting time and resources in conflict. Already some of their coworkers could come in to work only a couple of days per week, ration of gas not enough for more commutes than that, and the busses were jammed, could not take more people. There was less work to do, too, the whole economy shutting down as increasing numbers of employees couldn’t get to work to do jobs, and electrical power being shut down to the city and homes 25% of each 24 hours, to conserve fuel energy. It wasn’t a time to start a family either, so they chose to delay their formal wedding. Rumors were that if the trend continued, no gasoline would be available for use in one’s car, leaving only fuel for buses and delivery trucks.

The Creative Juices Flow

They began to bicycle to work from her place, and then they could comfort each other weeknights as well as weekends. And their creative juices flowed more and more. “Let’s brainstorm about how the problem can be solved”; no one was apparently preparing for shutdown of the personal automobile use, so they might as well have a go at, if only for creative fun.

Two weeks later, Marsha went to her Dad with a plan in hand, that she and John had produced during their nightly snuggles and daily long walks together, stopping at benches to sketch out quick drawings or to write details of a more complex idea. Paid projects had come to an end at NovelWay Prototypes; so to keep people busy for part time work there, he agreed to prepare a technology to get Greater Los Angeles back to work ASAP after total stoppage of use of gasoline in privately owned cars. He had three trucks which would still have some fuel alloted, being a business. One was converted for use as a bus for the employee’s commute to work; one was converted to deliver food and essentials to homes nearby; and the third was for delivery and installation of a demonstration transportation system’s first phase of usable development. Marsha’s Dad, Gerardo, felt it was his duty to prepare.

Pulling Rollerskaters

John and Gerardo finished assembling the prototype system past the front of his house in San Fernando Valley, a cable installed along pulleys and idler wheels, one cable around each nearby residential block, and kept moving by an engine pulled out of one of the cars

abandoned where they had finally run out of gas in the street, half a year ago.

The pull-along scooters with seats and carrying case were not yet ready for it, getting parts was very slow; so this test was to be done by using roller skates, heavy gloves and a pair of long grabber poles held by hand.

Several very skeptical members of the City Council were there to watch. The four converted automobile engines were started up, their throttles set for constant speed despite varying load, reminiscent of the original Watts steam engine governor mechanism.

Marsha insisted on being the demonstrator, she would not miss the chance for anything, since the manufacturing engineering of this system had been her baby; besides, her cute physique would perhaps distract attention from the inevitable glitches happening in any prototype test.

She stepped out of the house, with her roller skates already on, skated down to the cable which was now continuously running past along the street in front of the houses on the block. She skated under the cable, turned to face the direction the cable was moving, reached up with one of the pair of yard-long grasping sticks and slowly increased the grasping pressure on the cable with it, the cable accelerating her up to its speed, and down the street she went rolling along on her skates effortlessly, pulled by the cable.

A couple of minutes later she re-appeared, having gone all the way around the block; now approached the street intersection corner shared with the other three neighboring block-encircling cables. Just as the cable was to bend around the corner pulley, she let go with the grasping stick, coasted across the street

intersection, and with a bit of unpracticed effort she managed to re-attach the grasping stick to the next block's cable, proceeding on down the street, intersection passed.

Gerardo explained that this could be expanded block by block all the way to downtown Los Angeles and beyond, a way to start getting at least the somewhat more athletic people back to work. And the roller skates soon would be supplemented by the pull-along scooters with seat and carrying case, for use by most of the rest of the commuters.

And he continued to explain that as the workforce began to ramp up the available goods, a lightweight streamlined home-garaged type vehicle would replace the scooters, complete with automatic graspers and an automatic routing grasper interchange system coordinated to avoid collisions between vehicles crossing intersections. And that the commute system would be able to continue to evolve to far beyond that.

Marsha re-appeared coming down the far end of one of the blocks, came to a stop in her cute ice skater's outfit in front of the staring City Council members, and said to them "Well, is this better than what you have got now?"

Ethanol Power

Winter of 1975 (of this storyline starting with a "what-if" in about 1973) found Greater Los Angeles business waking up, employees getting to work and grocery store by the towed scooters and roller skates, which had become new manufacturing industries. Department of Transportation had insisted the pull-cable system be harmonious with the existing bus system, so the cable system was confined to residential areas and surface

streets, and was shut down twice a day for an hour while delivery trucks accessed residential areas.

The next evolutionary change, that to include home-garaged streamlined minimal-engined vehicles, was required to also be integrated into the existing vestiges of gasoline powered vehicles: car carriers originally carrying seven new cars, now carried thirty of the pull-band cars shuttling along express routes between downtown Los Angeles and the suburbs.

The railroad modified train cargo container flatcars to carry the pull-band vehicles, eventually provided a covering and a restroom and snack bar for each. By 1980 Detroit had bought into the Pull-Band commute technology, Los Angeles being unable to manufacture the new vehicles fast enough for the whole nation, especially since they were exporting them to the Far East while those countries also built up their own manufacturing capability.

Ethanol powered external combustion flash boiler engines began to replace the recycled automobile engines which had been keeping the system running most places up until then. Thin bands had long ago replaced the round cables, and higher-speed bands circulated toward the center of streets. The Pull-Band had built-in gripper acceleration locators along them, and the entire pull-band coordinated so gaps would allow cross traffic to pass through without thought.

Executives had Pull-Band extensions installed spiraling around taller buildings, delivering their management personnel direct to each one's office, their personal car parked just outside.

Tubeways and Light Rail

In 1985 the first tent-tube enclosed thruway between Los Angeles and San Francisco Bay area was installed, one direction per tube, a single stream of pulled vehicles so fast that they were lifted by air cushion, wheels no longer in contact with the ground, whizzing along at several hundred miles per hour, upper air column moving along with them as they tobogganed along down the environmentally isolating tube.

Personalizing one's Pull-band car became an art. Its external shape and interface to the Pull-band system was standardized along with total maximum weight of occupied vehicle; otherwise, the personal vehicles were modified as one pleased. The seat would be up for leaving room to haul groceries and a child or two; would recline for relaxed sleeping during long commutes.

Artwork often adorned exterior surfaces, and artists gained a new profession, hand painting the Pull-Band cars, some owners likely to change their art design as often as their wardrobe styles.

By 1995 Los Angeles had recovered economically enough to begin construction of a light rail system connecting downtown with Long Beach, North Hollywood, Pasadena and Santa Monica. Those light rail trains mostly pulled platforms where Pull-Band cars would be carried for the trips, although some seat cars were available for people on foot.

Licensing Technology

The NovelWay Prototype Shop licensed out the pull-cable and Pull-Band commute technology for only a token fee, figuring the faster the system could get LA up and in business again, so equally would their regular business get going again.

Their reputation grew as creative experts on moving things around by distributing energy via high speed moving cables and bands. Their innovation extended into technologies for coupling that high velocity movement to move along much slower objects and vehicles. As the Pull-band commute system expanded, increasing the number of users, the need to deliver much higher energy to the overall system at first involved stronger cables and bands, then high speed became necessary, the kinetic energy stored in the moving bands increased as the square of the velocity, so the same band at three times the volocity could deliver nine times the amount of energy to the movement of people and goods.

Next, magnets attached to the moving bands enabled electrodynamic drag to pull vehicles along without mechanical roller contact with the "graspers."

Permanent magnetic levitation bearings next allowed the magnetic bands to slide along without mechanical contact to anything, enabling higher velocities and efficiencies; the bands were broken up into short segments and the number of them launched down a pathway was in proportion to the system energy demand ongoing, especially useful along hundred-mile straightaways.

The curves of the structure soon required strengthening due to the high centrifugal forces of the high velocity

band segment aggragate mass changing direction; then that property was utilized deliberately in the vertical plane to arch the structure over obstacles and canyons.

With mechanical contact elliminated, wear dropped, and reliability was stressed in R&D for awhile, eventually the pathway of the segmented "bands" was enclosed in a hard vacuum, enabling electromagnetic energy coupling through the non-conducting tubing through which they traveled at ever higher velocities, energy losses now less than equivalent long distance electric power transmission wires.

The Envisioning of Rail to Space

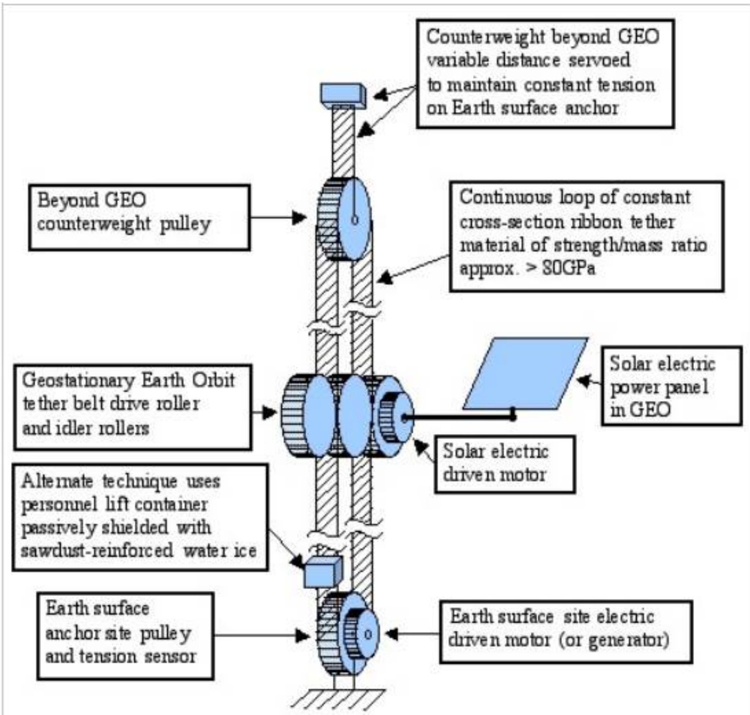
In 1988 the beginnings of an application of the Pull-Band technology's centrifugal force structural support capability was envisioned being developed to extend entirely around the planet, along an Orbital Transfer Trajectory shape extending from the equatorial surface around the planet up to GeoStationary Earth Orbit, 22,300 miles above the equator on the opposite side of the planet. Initial purpose was to lift construction materials to build the 1960's-envisioned Satellite Solar Power Stations, finally, direct access to power of the Sun up there, converted to beam down to Rectennas on the ground, to be converted and sent to commercial power grids to every country choosing the clean energy source. The idea began to flesh itself out, and NovelWay Prototype shop was enlisted to create the technology for the energy supported structure that would lift vehicles along itself up and down between ground and GEO.

Since the pull-band technology used magnetic bearings, electromagnetic drag coupling to vehicles, and centrifugal force to arch over obstacles, it was

relatively simple to extend it for the space access task.

Convergence of nanomachine development and micromachine advances, enabled such Pull-Band tubeways built of a few tens of millimeters diameter, so a warehouse sized structure could house the entire structure coiled on the ground, ready for a dynamic lifting through reaction principles.

Yet, it was not a finest hour for humanity; as it is said, life in the trenches is not well suited for lofty visions.



Building Up

J. E. D. Cline

Chapter 1 Catch a nano space elevator tether

Looking up into the clear equatorial Pacific sky intently, Improy could see nothing but blue and more blue. The radio direction finder had tracked it down to where it was now 30 meters somewhere above the floating artificial island, made of a converted pair of

surplus deep sea oil rigs. It ought to be visible by now, he thought. At least it was finally over the platform, the instrument indicated.

The implications of the existence of the tiny object there were impressive. A month ago it had been high overhead, 36,000 km, 22,300 miles, over his head up there, as it began its decent as the weighted end of a 120 GPa strong tether material being lowered. Another shorter tether with a heavier weight on its end had simultaneously been de-spooled in the opposite direction from the satellite, to balance the forces on the satellite from pulls up and down from tether masses in motion in a gravitational field. But the one interesting to Improy right now was this one on the downward tether's end. It meant that there now existed something that had never existed before in the history of civilization's great construction works: a continuous physical structure spanning the gap between high Earth orbit and the Earth's surface ... well, almost was so, and would be so when the object on the end of the tether got captured and secured here. The carbon nanotube tether filament itself was far too small diameter to be visible, of course. Even the 3 cm diameter shiny sphere was almost invisible against the bright blue sky over the Pacific Ocean, hardly telling of its recent journey across tens of thousands of kilometers of the hard vacuum of space, and then its dip down through the high atmosphere, all the way down to be paused here, as if uncertain if it really wanted to make the landing.

So he sent a beamed command straight up, which was received by the satellite far overhead in GeoStationary Earth Orbit. The satellite immediately obeyed and its solar panels pulled in energy to slowly unlock and restart the immense pulley drums, now almost empty of tether fiber. They slowly payed out two paired triple strands of single fiber carbon nanotube

from its remaining turns on the drum, one set of strands going upward while the other triple wound strand went downward. The drum with the upward strands wound on it was much smaller than the drum despooling toward the ground, as the upward strands went a shorter distance and also had a counterweight on it, the Earth's constant rotation angle's centrifugal force on the counterweight far beyond GEO delicately balancing to equality at the GEO machinery.

Down far below there, on the Earth's watery surface, Improy waited a bit impatiently for the propagation inertial wave of immensely tensioned falling strand traveling across the 36,000 km to where he was intently staring upward. He had been doing similar juggling for the past two weeks, and he was about to finally achieve his goal.

His gaze shifted over to where the still rough outline of where the third oil rig had been months ago, when this same kind of scenario had been playing out when a chunk of orbiting debris from a war-destroyed GPS satellite had severed the strand below GEO, and the falling carbon nanotube impacted that other floating oil rig island section, sawing it in two with the meteoric micro-saw blade. After that happened, all but he and his co-worker had left the floating island; the necessary technique and equipment had been proven anyway by that time, so now just the two of them were daring the fates.

It would be dawn tomorrow morning before the positioning would have stabilized enough for the capture attempt, so he calmed his impatience by going through the checklist and equipment calibrations for the big event. He wondered if he would be able to sleep this night, already tensed for action tomorrow; his shift would begin with the usual overlap of half an hour when

their shifts swapped, and would be timed to do the hoped-for initial capture in that time. With only two of them, and half an hour overlap at each end of their shifts, it still made the workday 13 hours long for each of them. Meantime, he knew that if the tether overhead got severed again, his partner would sound the alarm and they could hopefully prepare to survive it again. That was not likely to be happening again, was an improbable event last time. It is just that the memory of the impact last time was too impressive even now.

Below deck, Catalie was a bit impatient to get on with her duties, yet it was important to have one's 12 hours well spent in rest, rejuvenation, and self balancing. Her turn to shoulder all the responsibility would come soon enough. And one needed to be in the best shape possible, to cope with what was expected to happen and the things unplanned that might happen too.

In fact, this second attempt would not have happened at all if it had not been for her efforts. The improbable event of a severed tether at such a critical moment, causing the loss of the tether, part of their floating island, and three crewmen, had shaken all of them. The breakage had flung the GEO drum satellite out into distant space, while the earthward tether segment came violently down, so at least the space again was clear for another conventional launch vehicle lift of the backup Tether-drum robot satellite into GEO. But Ownma Corporate management had been all too eager to call it quits; she did not understand that. If they were so easily swayed to end the project, why did they start it in the first place? The lost resources were insignificant in relation to the massive wealth of the Corporation, so cost was not the real problem. Therefore, it surely had to do with politics or multiple motives. She never could comprehend the motivations of the rich and powerful, who bent their human intellect

not for the advancement of the ecosystem and civilization base upon which they thrived, but instead on acquiring ownership and power over all they could possibly grab by any means. What a waste of talent, was her opinion. Yet, fact of life, that those guys were the boss. Power and wealth must be as addictive as the hardest of illegal drugs, to get people to do that kind of thing, ignoring the often harsh consequences to such a vast group of people and living ecosystem. Surely their higher education had taught them that "absolute power corrupts absolutely" and thus ought to have enabled them to bypass that problem; but no, they just got sucked into it as if they had not been taught wisdom along with the raw facts.

Time for her shift to start finally arrived, and she climbed up to greet the late afternoon sky. Half an hour they had, to transfer over the duties of the task; and little time was left for companionship. Improy pointed up into the sky, and yes, there was a flicker of reflected sunlight off of something in the sky. They inspected the autorecording log of position of the object, found the expected shrinking average separation as well as the rhythmic rise and fall of their own position with the lunar tides. There was enough general pattern in the log's curves, so that another correction would be sent to the GEO satellite overhead about midnight, which hopefully would result by midmorning the next day of the centering of the glittering tiny object's position over the vertical shaft in the floating platform, within which the tether end attachment would ride up and down with the tides and waves, as the project began its next phase.

The next morning the two of them stood watching the three cm diameter tetherball, seeming to hang from nothing, the microscopic tether with which it was suspended invisible against the blue sky. Inside the tiny tetherball was just a high powered ID tag, which

was briefly powered up by a continuous beam of energy, which was received and converted into energy to power a transponder pattern modulated transmitter while it was receiving the power beam, sending its identification signal out for radio position location. Its signal was only to show where the end of the tether was at, providing the data by which it had been guided to where it was now, on average over its target on the floating island.

Improy picked up his fishing rod, which had been outfitted with a capture snare loop fishing line, and he brought the end of the fishing rod up near the tetherball, which was not standing still, due to all the motions involved from wind and waves and tidal action. Back and forth the snare loop went, while he got a bit of practice with the sport. Then a couple more intent motions, he had the tetherball snagged on the pole's fishing line. Catalie documented the moment of capture in the facility log, and marked the video recording moment. As simple as the thing was, it was a historical momentous event, in reality. It was the instant of the first connection of the earth surface and high earth orbit, by a continuous physical structure!

He transfered the fishing line down into the vertical tube going down below deck into the floating former oil rig, while Catalie went below deck to connect it to the plunger that was the next phase of the connection permanently to high space locations. Then he transmitted the command to the GEO satellite overhead to again lower the tether, this time some ten meters worth. Going below deck too, he did a QA check of the work Catalie had done as the last part of her shift. With ten minutes to spare, they celebrated together in happy embrace, and each had a small glass of red wine to toast the achievement, all alone far out here in the vast Pacific Ocean.

The next day, they had the end of the carbon nanotube dual triplet strand tether locked into the vertical shaft. All work done on it would be done remotely, as the end of the tether rode up and down the tube in response to the ever-changing environmental conditions. The next step was to begin the unwind process, to separate the two triplet helix strands from each other, which would begin down here, and gradually unwind all the way up to GEO. The 120 GPa strength nanotube material was plenty strong enough to bear its own weight to GEO, thus enabling a very simple scaling technique.

But first the remaining tether material on the drum in GEO would need to be de-spooled downward until its final loop was all that was on the drum, which thereafter would act as a pulley. The untwisting of the original nanotether needed to be finished after that, ending with two parallel nanotethers consisting of three wound strands of monofilament carbon nanotube material. That done, a strong splice would be done at the bottom joining the two triple-strand tethers to form a continuous single loop between ground and GEO. The electric motor on the drum - now pulley - in GEO, powered by solar energy, would pull the belt around, and another strand of carbon nanotube would be fastened on at the bottom and would be pulled up alongside the rising side of the belt between the pulleys. Gradually the girth of the tether belts would thus be increased until it was able to carry useful payloads to GEO, solar powered lift at that. Much easier than use of climbers, and far more energy efficient.

Chapter 2 Scaling the space elevator up

The drum in GEO had finished de-spooling the remaining twisted carbon nanotube tether, leaving only the half loop around the drum, and all the tether material was now dangling toward the Earth.

And on the floating artificial island, Catalia and Improy had their hands full. They had to do everything remotely into the tube which constrained the motion of the tether's end, in the relative motion from wind and tides. The two triplets of twisted nanotube monofilaments, almost invisible to the eye, were separated out, and each was securely clamped to the unwinder fork. Then the two sets of strands were slowly unwound, counted to match the number of twists applied during the original manufacture of the spooled tether. The number had to match exactly, otherwise there would be a crossover somewhere, and abrading would happen once it went into motion as a belt between the two pulleys. At the same time it was untwisted, there had to be absolute restraint of both strands sets, or there was risk that when they were finally untwisted completely, one strand would be slightly heavier than the other and begin to fall down, raising the other strand set up, making it even lighter, and causing cascade failure collapse of the structure, dumping it all back to the Earth surface.

And they had to splice the two triple monofilaments together as a final step, attached together so securely the joint could bear the load of the entire weight between GEO and surface. The splice had to be made when the two strands were freed from one another, their most vulnerable time for weight unbalance pulling one side down. And the excess length had to be snipped off to a length that would

never bottom out in the vertical path constraint tube on the floating platform.

Although the whole process had been thought out long ago, it had never been done in physical reality. So each step was part per the book, and part was winging it as the process unfolded in physical reality, truly massive forces in delicate balance.

The couple now worked on the same shift, as the tasks required their close coordination hour after hour. Catalie's intuitive sense of the overall wholeness of the ongoing unfolding events, was balanced by Improy's continual referral of the procedure, and entry of data or marking of checkboxes. Occasionally they would modify or insert the instructions to some facet newly become apparent.

When some stage of the procedure allowed them relaxation time, as lovers they renewed their bonding so helpful in the ongoing tasks of the day too, contributing greatly to its chances of success. What they were doing would have taken dozens of experts normally, but those experts were fearfully far away, memory of the destruction in the previous attempt keeping them away. The internet provided access to their advise, as well as a way to give them updates on the ongoing progress details. But the lover's sleep together time and recreation break moments were theirs alone, and savored to the fullest.

During one such break time, Catalie called Improy over to look into the stereo microscope. She had a hobby of observing a particular kind of sea critter, a kind related to the little rolley-polley pillbugs in her garden back home, yet which had amazing diversity on the vast sea floor. Peering into the microscope, Improy was immediately plunged into the microscopic world of

marine crustacea, and he saw one of the males, with its pair of tail-like hind structures and a pair of horn-like structures on its head, scurrying around with three small versions of itself on its back. "See how the youngsters scurry to get on the back of the large male when a threatening situation comes along", Catalie guided. "There is more to the lives of these sea creatures than one would expect. See how their big eyes sometimes seem to be aware of you looking in the microscope down at them." Improy grunted something noncommittal, but then looked over at the computer display which was the output of a tiny camera mounted on the outside of the floating platform's shell, long encrusted with the makings of creatures that inhabit the pilings of waterfronts around the world. "Somewhere, sometime, in its past, this oil rig must have been located off the California coast. These are the same Sphaeromatid species I found on the marina pilings in the Los Angeles area a couple of years ago", Catalie chattered on. "No way could have gotten here through the ocean on their own." She too watched the computer video display of the busy lives of the teeming microvillage on the hull of their floating island, one of her favorite relaxations. In so many ways they are like bunches of people. "Yet they are so tiny, and look as strange as the "bug eyed monsters" of early science fiction writers fantasizing life on other planets, yet here it is, right here." Tiny but cute bug-eyed monsters, neighbors only tens of meters away from where the adventure of connecting to high earth orbit was unfolding. She turned off the microscope light, picked up the petrie dish and carried it off, and soon Improy could see the little crustaceans dumped back into the view of the micro videocamera mounted on the outer hull, where they scurried around frantically until re-discovering their homes.

Breaktime over, they went back over to the structure which had once held oil drilling machinery, now housing the mechanisms preparing connection to far above instead of to far below. The untwisting of the pair of triple-monofilament carbon nanotubes was getting close to completion. The exact untwisting was determined by sending a pulse up the separated pair of tethers, which would send a reflection back down early if the two crossed somewhere below GEO. When there were no lower reflections happening, the untwisting ceased; the tether was allowed to stabilize then to verify that indeed the two sides were parallel and no crossing existed anywhere in the 36,000 km length.

Halfway down the 50 meter long vertical tube in the seagoing platform, a fresh pair of clamps were applied to the two strands as security. Then just below that, they severed the excess tether length, unraveled the three monofilaments, then re-wove them into a section of six interwoven monofilaments to form the splice. The spliced area of the tether was then surrounded by a vacuum chamber, where it was pumped down to a hard vacuum, then a flood of carbon atom gas was deposited all over the splice area, the atoms aligning themselves to unite across the original strands, strengthening the bond within the splice. A plastic sealant was then applied over the area, a plastic that would protect the area from oxidation during its ascent through the atmosphere into the hard vacuum above, where the sealant plastic would vaporize, its job done.

Then the big test began. Command was beamed up to the drum satellite in GEO to roll the pulley, lifting one side of the pair of tethers and lowering the other side, it all in a great loop at this point. Clamps had been removed down below, so the splice went up and soon through the atmosphere, as the continuous belt went

around between the two pulleys, one in GEO and the other in the tube on the floating artificial island. It was days of wait, as the drum rotation was constant and the distance great, The load on the splice increased to a maximum as it reached GEO, then was bent as it passed over the GEO pulley, then supported the full weight of the downward tether. And it held.

Their next milestone was to attach a fourth carbon nanotube filament to the upward moving side of the loop, seamlessly laying it along the twist of the original triplet of filaments as it rose. This required a bobbin containing the entire length to be emplaced for a full up and down distance, 72,000 km of nanodiameter carbon nanotube filament. Splice of the added filament ends were arranged to be ten percent of overall tether distance, so as to not overlap yet being of some assistance as the original splice neared the top of the tether. This was the proving out of the scaling up construction process, key to an economical construction of a Space Elevator of sufficient girth to be able to lift the materials needed for huge constructions works high in orbit.

When two more strands had been added, they were able to begin adding two new strands per loop movement, exponentially increasing the rate of increase of girth of the overall tether pair. Eventually the additions were done laterally, gradually forming the tether into two parallel ribbons that flowed between the earth and space pulleys.

When the weight of another layer of ribbon girth equaled the weight of a solar panel for the GEO satellite, for the next several circuits of the tether loop, instead of tether material going up, solar panels went up, clamped on the ribbon as it left the deck of the floating island, and stripped off just before reaching the

pulley in GEO. The original design of the GEO satellite had provision for robotically distributing and attaching the added solar panels, which enabled lift of greater loads up thereafter.

The increase of tether cross-sectional girth then resumed, until the tether could lift a small spacecraft carrying a person to GEO. The limits of the original chemically powered launch vehicle emplaced satellite to expand itself had been reached, and construction of the larger facility in GEO required human presence from then on.

Tugs brought in more surplus floating oil rigs to be lashed to the original remaining pair of platforms, and an influx of personnel flowed back to populate the increasingly large artificial island there in the equatorial Pacific Ocean. The continuous existence of the dual tether increasingly gave people confidence of probable survival, especially as its girth and therefore strength became quite substantial and would be able to take a hit from increasingly large orbiting debris and still survive to be repaired.

The scaling up of strength of the tether again ceased, as more solar panels were sent up, then Improy was lifted up the tether in a mini-habitat.

Arriving in GEO, the habitat module was unhooked from the tether, and Improy spacesuited went out to begin assembling the new solar panels to increase the power of the drum lift, and soon a second electric motor was lifted up and joined to increase the lift power of the tether. The rate of tether loop movement was then speeded up, reducing the lift transit time; more components of the initial permanent manned facility were lifted along with sawdust-laced water ice which was placed around as a passive shield

against solar storms that eventually would pass their way.

Improy had only a week up there before the DNA repair mechanisms were getting used up in his body, so he went back down to the artificial island to recuperate, providing excuse for a huge celebration of having shown human travel to orbit and back on a space elevator for the first time.

Chapter 3 Building too briefly in GEO, and a small solar power satellite

The porthole tunneling through the 3 foot thick shell of ice shielding the small habitat in GEO, was unwaveringly centered on the disk of the Earth far below, as all other directions were at risk of radiation coming in. Munching a sandwich, Catalie stared at the watery planet below thoughtfully. "Why did they say to stop lifting ice for shielding here?" she asked Improy. He paused from getting into the exterior access worksuit, grumped that he did not believe Ownma Corporation really wanted this project to succeed. The corporation's long time big holdings were in the conventional rocket launch technology aerospace technologies, that is where they made their big money. "Every time we have had a big success here, Ownma management makes a big show of handing out bonuses to its regular launch system personnel, and pointedly passes us up. They make clear to everybody, that reward only goes to the staid conventional folk, no matter that we here have done almost miracles to keep the project going." He finished assembling the worksuit around himself, went into the airlock, and soon was out in the environment of deep black and brilliantly bright complex structures.

Well, today was not a miracle day for achievements per management far below; but to the visionaries of the 1960's, today would have been a dream come true. He inspected the microwave power input connector tightness with the torque wrench, then moved over to the hinge pont of the 200 meter long truss, and activated the motor that began the slow deployment of the immense diameter, but low mass, parabolic antenna. When it was extended out straight, he sent the signal to switch to active gimbal positioning,

so that it was essentially decoupled from the motions of the truss arm.

Back in the habitat, he found Catalie having an internet video chat with their 7 year old daughter, Idealiana, who was down on the floating island. We will be back home with you in just a few days from now, don't worry, she soothed her child. Improy floated over to the power console, and saw that the oscillations in the big antenna out there had dropped to an acceptable amplitude, so he activated a video link to the rectenna receiver site in the southern California desert near the Salton Sea. "Coming at ya" he said and activated the relay which switched half of the solar panel electric power output to the microwave generators driving the antenna he had just deployed. "Got it!" came back the reply from the ground rectenna site. "Three megawatts, we are now dumping into the California power grid!" continued the report. It had been easier to use the power grid as the initial load, rather than a huge bank of resistors for the brief test, so right from the first, they were making money. Not much money, true, but at the current cost of basic energy of a half dollar per kilowatt hour, every little bit would help. And this was very clean energy.

Approaching the little artificial island was one of Ownma Corporation's finest executive yachts, on time for the expected test of solar-derived electrical power input to the commercial power grid. Relaxing in the immense lounge of the yacht, Stebler pondered the potential effects if the test succeeded. He oversaw the company's vast holdings of coal-fired electrical power plants, as well as the fuel suppliers for the major chemically powered space launch facilities. The cost of their operations had been going up steadily with the drop in coal and fuel resources that were economically recoverable, and the CO_2 production and particulate

pollution control costs were driving up expenses to a level where the major stockholders were registering complaints about him. Stebler had the responsibility or maintaining everything in steady balance, consistency of results was paramount. And his competancy was like the Rock of Gibralter.

Theo, the brilliant genius who locked the workings of the Ownma Corporation's vast empire into a sound theoretical basis, joined Stebler in the lounge, receiving a refreshing drink as he sank down in another of the plush chairs. Without preamble he said "If Solar Power Satellites do become reality, they will disrupt the financial foundations of the Company. Large amounts of very clean energy derived directly from the Sun's energy as received in space high above the earth, and beam-able to customer nations all over the planet, will cause our customer base to shift to that source of energy, abandoning us."

Stebler stared at him for only a few seconds, then spoke with his deep commanding voice "That would de-stabilize everything. It would be a terrible thing. Such disruption would reverberate throughout the world, causing incalculable damage to our corporate foundations. It must not be allowed to happen." A pause, then "This is our own project, why did we start this in the first place?"

Theo shifted uneasily in the plush chair, torn by conflicting data, memories of decisions long ago, finally speaking. "In the year 2000, despite our long suppression, a paper got published anyway. It outlined a way to bypass the requirement of superstrength tether material for building a transportation structure linking ground to high earth orbit, that would enable cheap construction of Solar Power Satellites and other huge facilities for utilizing space resources thus

attainable, perhaps even a vast space based commercial empire.

"As long as people believed there was no way to build a Space Elevator, our corporate economic vista remained solid into almost forever, we would become the ultimately powerful, no one could challenge us. The world would become ours, no question. Civilization depends on two things: abundant energy and abundant knowledge. We focused on the energy aspect. Without plenty of easy energy, knowledge would become increasingly uninfluential, ceding control to those who controlled energy.

"So we chose to revive the original anchored tether space elevator concept. Carbon nanotube technology looked like it might result in extreme strength to mass ratio material eventually, so it would seem plausible to put money out there to get people focused on that kind of physical space access structure. And the key result would be that any interest in the concept of building a lifting structure between ground and GEO by using kinetic energy stored circulating centrifugally within a structure, to become forgotten, even considered a rival. And it worked. The old guy who was trying to get public awareness of that concept faded away, and given a few extra pushes into obscurity along the way by our staff's guidance.

"But we were stuck with having to show progress in making an anchored tether space technology work. There were plenty of ways for it to fail, yet there were a few determined people who did not comprehend the reality that it must eventually fail, so as to maintain the world energy supply status quo upon which all rests."

Stebler also had a refreshing drink as he listened to this, reclining in the sumptuous chair. Silence

passed, minutes. "This I have known from the beginning. What I need to know is why hasn't the project failed already? It is a wacky idea, space elevators and all. I don't believe all this is happening. But stability will be restored, all will become back to normal. Have no doubt."

On the little floating island, little Idealiana chatting with her Mom so far above in GEO, also watched as the huge beautiful yacht grew close, then the biggest helicopter she had ever seen landed on the deck of the island. A pair of men got out of the flying machine, spoke briefly with a greeting congregation, then headed straight for her. She returned her attention to the image of her mom on the internet video connection, chatting a bit less happily.

Up in the GEO habitat, Catalie listened while Idealiana said someone wanted the internet chat connection with the GEO station; then Catalie saw the powerful figure of a wealthy dressed man go onscreen. She quickly called Improy over to continue the link chat. Improy cheerfully started the conversation by saying they were now making $1,500 dollars an hour off the energy they were supplying to California. The heavy commando voice replied back "This project has been costing us $3,000 a day, and stockholders want their money and now. Switch the remainder of the solar panel output power over to the power beam, and return to the ground. Your job is over" and the screen went blank.

Improy and Calalie stared at each other a moment, then he said "See what I mean, they reward success with rebuke. Makes no business sense. We are now set to go for a full sized Satellite Solar Power Station construction here to make the big money delivering the finest electrical power around the world,

and instead he wants to chop it right here."

Improy went back to the link to the rectenna site, and said "Here comes $3,000 dollars an hour at ya, enjoy, 'cause that is all you will get from us. The Big Boys have spoken." He shut down life support and the construction engines, switched all the solar power except enough to power the ribbon pulley drum for the vehicle's return, over to the big dish antenna out there. They hopped into the lift's captive ribbon capsule, and with a longing look back inside the station they had created so lovingly with daring courage, sealed the hatch and down they dropped toward the watery blue ball far below in the vast night.

Chapter 4 From tether to torus

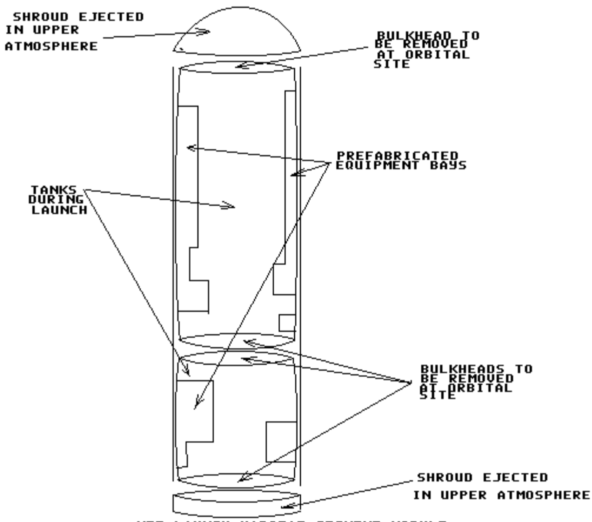
When the tether belt had lowered them to within a few miles of the ocean's surface, Improy pointed out the gleaming shape of the Ownma Corporation's mammoth yacht cruising northward from the tiny floating island which it had dwarfed. When the Armed Services had been privatized, Ownma Corporation had been ceded the U S Navy, and the Corporation promptly had one of the nuclear powered aircraft carriers modified to be a luxury yacht for their management to sport around in, traveling to and from by air. "At least we won't have to endure the "in your face" insults from management this time," he quipped. He had learned the hard way that is a favorite sport of the Big Boys who ran the Corporation, the in-your-face put-downs, putting you back in your place if you had done something unusually well. Even knowing it was just the playout of an inborn psychological quirk of the bullies that compulsively went for the domineering of others that brought them the easy good life, still did not take the sting out of that kind of "reward."

Silent for most of the decent, Catalie replied that they had experienced some wonderful life together in this adventure, surely reward enough in itself. And Ownma Corporation had enabled that to happen, she reminded him. "They only did this to watch us fail in desperate effort, and the best we could do is to deprive them of that goal," he grumped. She shrugged her shoulders, saying "Well, I had fun, and still am having fun. This is one of the greatest rides I have ever had, for instance. Can't you just enjoy this ride?" Improy just stared out the window into the air, then said "I remember long ago working with a man who had a phrase he liked: 'Easy as taking candy out of a baby's mouth' which I think says something about the mind

behind the person, it does. Ownma Corp bosses did this project for the same purpose they would put the candy in the baby's mouth in the first place, just to get their kicks out of taking the candy away again, what power they relish" he bitterly muttered. "So what are they going to assign us to do next?"

A month later they found out. The plane carrying them landed at Holloman Airport in Alamagordo, and then they were delivered by van to Ownma's White Sands desert holdings, granted to the Corporation by the government when privatizing the former missile test facility, where American's had gained rocket expertise by test firing German V-2 rockets they had captured at the end of WWII, then learned from test firings of missiles they designed and built on those principles. Now it was a spaceport for the chemical fueled rockets that were a mainstay of the Corporation.

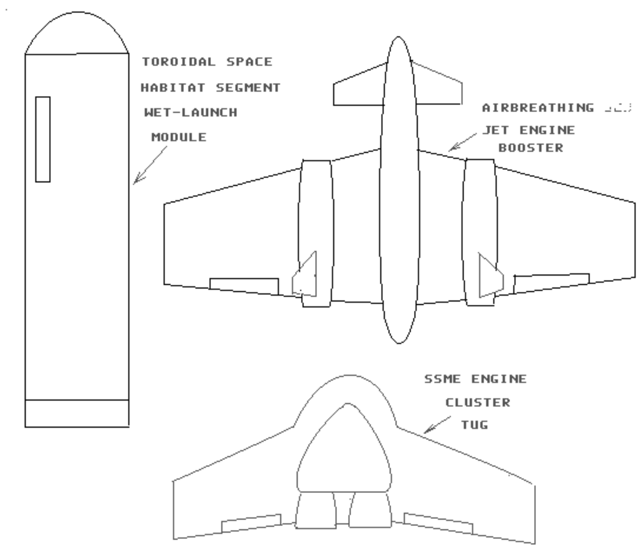
At least the couple got to work in the same facility, so they could have lunch together in the company cafeteria. Munching lunch while looking out the window at the rugged outline of the Organ Pipe Mountains, Catalie chatted that she had been assigned to work in one of the strangest shaped kitchens she had ever seen. The kitchen was one of two that together prepared food for a thousand people, all of whom would exist in a mile-diameter wheel being assembled out in the desert near the launch facility. She was told to contribute to the design evolution of the kitchens, while bearing in mind that each section of the wheel-shaped tubular building, would be reconnected after being twisted around 90 degrees, so that the floor would later be where the outer perimeter is now. Additionally, the tubular sections, which were 10 meters in diameter and 40 meters long each, had a peculiar design that insisted that everything be sealable into the wall areas, keeping the central area clear; and there



were strong bulkheads at each end and one internally, although oddly not making equal size sections. "That is because", Improy commented, "each of those tubes will be filled with liquid, one section with combustible fuel and the other with oxidizer, and the whole thing will for awhile become a huge fuel tank for its own launch into Low Earth Orbit." "Lets take a walk over to the hangar, before we go back to work."

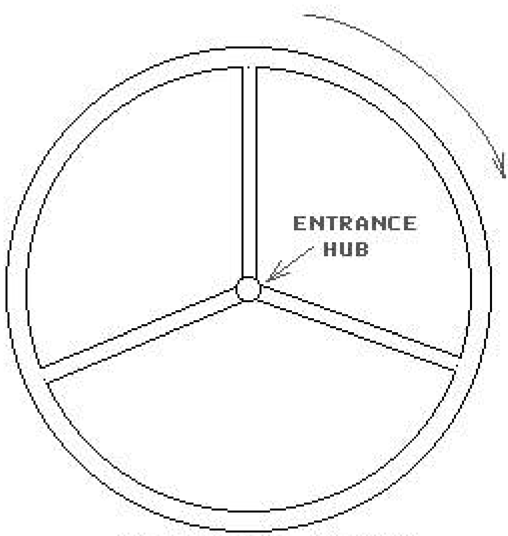
In the hangar, he pointed out there were two kinds of vehicles in there. One was a sleek pilotless aircraft with huge airbreather jet engines. The other was a short stumpy lifting body winged shape that was mostly three huge engines with wings, which clearly had inspiration from the old Space Shuttle re-entry vehicle, but without much of a fuselage; and also no place for a pilot. "What is to happen, is that the kitchen you are helping debug now, will be one of the individual modules that will be set upon one of those short stumpy

vehicles with the huge engines; the nose fairing will be transferred over to the top of the module for the trip up." Pointing over at one of the sleek aircraft with the two big engines on its wings, he continued "And one of those airbreathing boosters will be strapped onto the module too.



The insides of your kitchen, or whatever habitat module being launched in the moment, will be filled with fuel and oxidizer, each in its own section, separated by that inner bulkhead you mentioned." Taking off vertically from the launch pad over there, the airbreathing booster will use up nearly all of its fuel by the time it reaches 30 km altitude, then it will disconnect in the upper atmosphere, and fly back to land on the airstrip here; while the stubby engine tug module will continue to burn the fuel coming from within your kitchen module or whatever. Put that way into Low Earth Orbit, each of the modules will be teleoperated precision docked to the previous habitat module already up there, gradually

assembling a spoked wheel a mile in diameter. The connection up there, however, will have rotated the kitchen module so that its floor is now on the outside rim of the big wheel." The engine tug module will disconnect from the habitat module, accept the nose cone which had been disconnected from the module before it was docked, re-attaches to the engine tug flyback module, which then de-orbits and returns back here to White Sands airstrip. They expect to launch



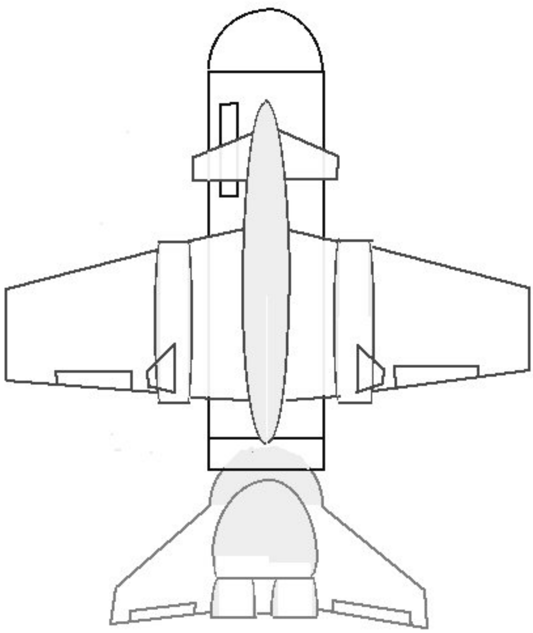
THREE-SPOKE HABITAT

1 MILE DIAMETER

236 EMPLACEMENT LAUNCHES

three modules a day, on average, this way. Ninety modules a month. And when there are vehicular losses as inevitably will happen, there are spare modules and boosters to take their place." Catalie did the math in her head ... 1 mile diameter ... 125 feet per module ... 150 flights including for spokes ... 90 modules per

month ...."So we are going back into space in two months when this thing is finished put back together in a circle up there?" she asked. He nodded a yes.



PREFAB HABITAT MODULE LAUNCH VEHICLE ASSEMBLY

Dwn 1998 JEDC

In reality they were another two months debugging the wheel-shaped space habitat as it sat on the ground. Its solar panels received only a tenth of

what they would have in space, so the energy to run air conditioning inside was marginal, during the hot summer days of New Mexico. Debugging the far too many interactive systems, both machine systems and living systems, all of which had to operate within certain ranges of the parameters, had some wild swings in some values that had to be stabilized adequately before it would be ready to be put into space. And the first test launch of a basic module failed, the coupling between the engine tug module and the module wobbled when the extra thrust from the airbreather was suddenly stopped, causing fracture of the coupling and requiring destruction of the vehicle by the range safety officer. Reprogramming the airbreather thrust profile so that it tapered off gradually before disconnecting solved the problem, and the second test launch achieved the orbiting of the habitat module used for the test, an essentially minimally equipped module to be used as a recreational facility. Yet there it was, in Low Earth Orbit, with an orbital path that would take many years before risking collision with the tether of the Space Elevator.

Two months later, Improy and Catalie were approaching the torus space station in a Rutan passenger space shuttle, both equipped with space worksuits like the one he had used at the GEO faclity. Their first task was to attach one end of a fiberglass cable to the outer perimeter of the wheel, then she sent her worksuited module along verifying that the cable correctly slipped into a channel along the outer perimeter, while Improy guided the cable bobbin despooling around the 5,000 meter circumference of the wheel. When the full length had been roughly laid, they went along and secured a pair of u-clamps at each place where modules had docked together.

With that emergency ring in place, they then similarly put a pair of aluminum ribbon cables around

the perimeter, made of the same material as the module shells were made of, for thermal matching. With a small space scooter he used its rocket thrust to work the plane of the wheel so that its axis of rotation would be normal to the direction of the Sun when spun up, making it a giant gyroscope. Then they both moved off to a safe distance while Improy activated the rocket engine mounted on the outside of the huge wheel, and it began to rotate. They only brought it up to a 5 minute rotational period, which temporarily would provide a usable artificial gravity inside, while they began the internal setup of the facility.

Approaching the hub where the spokes joined in the center of the giant wheel, they pulled the first of some 400 bulkheads that would need to be removed, off of the end of the hub module, exposing the airlock built in there. The bulkheads would have to be secured along the outside of the hub one at a time as they were removed from the interior, brought through the interior and out through the other end of the hub module. They verified that this could be done, clearing the path from the hub down to one of the modules of the torus wheel itself, the winch operating easy in the small artificial gravity.

At that point, they sealed the airlocks at one half of the hub, filled it with air, opened their space worksuits in which they had now toiled for days, and breathed new air inside the module. Lights on powered by the solar panels outside, air conditioning stabilizing internal temperature, they activated the computer terminals linking the station with Houston by radio link, and was greeted with the fanfare blare and video clip from Clarke's "2001 Space Oddysey" movie, showing the rotating wheel envisioned so long ago.

Chapter 5 Tedious removal of internal bulkheads

Lounging in the habitat module which they had made habitable as a 1/5-g shirt-sleeve environment, Catalie was in one of her rare philosophical moods. She mused outloud "I would think that people could rally around a project, like this one or the Space Elevator we worked on. But maybe the reality is that people only rally around other people. Even 'rally around the flag, boys' is actually rallying around those who are happening to be carrying the flag, the flag being more easily seen and identified as a direction to go toward, a symbol vaguely defined as 'here is where the goodies are, follow me.' A project has no ability of its own to get anything done. It is people that do things, not projects. The closest it gets is when an individual uses the project, as if a flag, to get people to rally around him. A project getting done is an indirect thing, then, at best. Even though it is the project, not the person pushing the project as if it were a symbol of himself, that fills the needs of people."

Improy was only partly paying attention, being engrossed in setting up an instrument. "So why did this space station get created?" he absently countered. "A project starts as a dream, a non-physical fantasy; yet is a map to where the goodies ought to be found. Isn't following the trails on a map, making it happen?"

A timer sounded, ending break time. They assembled their worksuits around themselves, pumped the air from the room back into storage, opened the bulkhead, and moved out into the well-lit wheel interior. Moving around the rim at 1/5-g, it was more a hop, little different than Lunar gravity Moonwalks of the early 1970's.

They were still at the tedious task of removing all the interior bulkheads, stashing them lashed to the outside of the central hub, for now, just to get them out of the way. Their material would become raw material for fabricating things when the workers arrived and began living their lives here; but for now, the bulkheads were just in the way of progress. Arriving at the next sealed bulkhead, they both worked together to loosen each bolt just one turn; then paused as the remainder of the former propellant still in there was vented through the cracked seal, expanding down through the open channel to the spoke and out through the open airlock at one end of the hub. When no significant gas flow was observable, they finished removing the rest of the bolts, pulled the bulkhead off, and together hauled it down the rim until reaching the nearest spoke tube, attaching the bulkhead to the electric hoist's cable, and Improy rode it up so as to steer the thing so it did not swing against the wall of the spoke's interior. Catalie joined him where the spoke joined the hub, and they slowly pushed the bulkhead, now in free-fall yet with considerable inertial mass, out through the open airlock while a security line on it, took it outside and lashed it to the exterior of the hub. Then they went back in, reversed their path, back to the newly opened habitat module. They then inspected the module for damage, and opened all storage doors to vent any residual propellant. when the newly added 40 meter section's gas level was down to nearly zero pressure, they headed for the next bulkhead. Since the space behind each module internal bulkhead, or behind each double bulkhead where two modules had docked together, was alternating fuel and oxidizer, so they wanted very much to have essentially all of the preceding chamber's gas gone, before letting in the other component of propellant into their space. Although the partial pressure would surely be far too low for combustion, they took no chances, for there were plenty of tiny

sparks happening as switches and relays operated, such as those providing their lighting.

It was dull and repetitive work, yet needed to be done carefully, and in places laboriously. When they reached a juncture to the next spoke, they would open up that spoke all the way to the hub, shortening the distance needed to hustle freshly removed bulkheads up and out. There were six spokes to the wheel, so there were 21 modules to go through, each providing 3 bulkheads, before getting to the next spoke.

When they had three spokes cleared, it was time to change the activity for awhile. There were six of the modules which had airlock double doors built in where the inner bulkhead would have been, one door was sealed during the launch, serving the function of a bulkhead separating fuel from oxidizer during the ascent. So they returned to the originally cleared out section and sealed off the airlocks at each center point between spoke connections, and closed the airlock at the hub connection of the spoke, making an enclosed area. They filled this enclosure with air, and activated the life support systems for the almost 840 meter long livable habitat area. From then on they were able to return to this shirtsleeve environment for break-times and sleep periods, a very welcome improvement in their lifestyle.

They were able to utilize some of their rest periods for testing of the life support systems. One such was to activate heaters pouring a large amount of heat energy into the enclosure, equivalent to the heat given off by a thousand people, and watch the air conditioner system adapt to that situation without oscillation beyond tolerable temperatures. Such a situation could actually happen, if one 60 degree arc of the wheel became the only habitable section, and so all thousand of the

personnel would have to cram into the 800 meter long section.

Catalie was first to point out that since there were only two kitchen - restaurant areas in the whole wheel, what if the only habitable area were one of the other 4 sections that had no food facilities? She had instinctively had them seal off a section which had been pre-equipped with kitchen facilities, since that was where they would have break-times and meals, as well as sleep times. "So what happens if it is not this section that survives a disaster, and everyone has to hole up in the next section? How will they eat? There is more to life than just working and hanging out motionless until next time to work, you know." Improy paused, looking a bit startled. "Yes, they have inputs and outputs that occasionally need to happen, to live. Even some private space and time for lovers to bond for sanity renewal ... yes, how will they have that if they are holed up in the machine shop area next door?" They included this insight into the next evening's report back to headquarters at Ownma's White Sands facility.

The reply came back several days later: since the launch system comprised of the airbreathing booster, the engine tug flyback module, and the habitat module had been perfected to great reliability during the construction launches, they had modified one of the basic habitat modules to have no structure consisting of built in facilities, and was instead configured to be a one-way space bus for some 33 people each. Since the personnel were nervous about being launched into space and docking up there in a vehicle without a pilot, they were going to test the modified vehicle several times, so expect to have some modules show up which had porta-potties and bins full of prefab foods and drink, to be distributed to segments lacking in restaurant facilities. Each of these test modules,

assuming they arrived as planned, would have to be unloaded, and the empty cylindrical module lashed to the wheel's hub for later use as raw material. "And, the third launch once the system has proved reliable, will bring up 33 brave souls who are wiling to fly without a pilot, and join you as early crew members, living in the section you have proven out responsively livable. Get ready for company."

When a porta-potty shipment arrived docked temporarily with the hub a few weeks later, Catalie noted in the log that there was an unusually long time between arrival and actual docking clamp activation. Improy grunted some comment about it was because the vehicle considered it beneath its dignity to be ferrying outhouses, probably projecting his own feelings about having to tote them manually all the way to positions within the wheel's circumference. But Catalie put it on her worry list. A second delivery of the "one-way space bus" system also had a similar unusually long stabilization time before the now essentially automatic teleoperated docking, human operators no longer needed to pay attention to the docking process.

Both of them were in the Embarcadero, as they called the port control facility, watching as the first shipment of live people hove into view, video links showing a bunch of tense-looking people inside the cramped passenger area. The automated docking, however, was taking a very long time to lock together. The video link showed people's heads and bodies being swayed a bit in their seats as the positioning thrusters jerkily fired again again. Catalie exclaimed "the docking feedback loop is phase shifted by the shifting masses of the passengers! and the system is in oscillation mode." Improy saw it was so, and checked to see how much thruster fuel remained. None, actually. They looked out at the space bus module, just less than

a meter from the docking port, but now out of docking positioning fuel.

He bolted for the airlock, dragging his worksuit along with him, got into the midsection of the airlock, assembled the suit and sealed it before the air was pumped out of the airlock midsection, the outer door opened, and he saw the nose of the huge cylinder had drifted another meter away and twisted at a 5 degree angle, getting worse by the second. Connecting his safety tether to the station, he scrambled over to the storage to get some of the tie downs used to lash the bulkheads to the outside of the hub. Clamping one end of one of the tiedowns, he jumped to the nose of the 10 meter diameter space bus, ran the tied down rope through one of the still closed docking clamps, secured it. He radioed Catalie to tell the passengers that they were going to stay up here for now anyway, but how to get them connected and inside was yet to be determined. She radioed back that the perspiring passengers inside were visibly relieved to know that they were not going to become part of a meteor re-entering the atmosphere after all; it was not designed to return gently to Earth.

Improy went back inside and de-suited, crisis over for the moment and he had been on excess adrenalin long enough. "The mass of that thing is far more than our worksuits can control", he pointed out to Catalie, once he had stabilized his heart rate. How can we get it back aligned with the docking port, and brought against it to fire the docking clamps? They have no airlock or spacesuits in there, they have to come through the docking hatch." They were silent for awhile, thinking. Improy asked, how much air they had left in there ... no one knew, but not likely much, as it was not intended for long term occupancy. And the porta-pottys delivered before had no need for oxygen.

Not likely this one had extra oxygen either. They watched the tense faces inside the module, on their computer terminal screen.

Back in his worksuit, he went into the airless part of the hub, and disconnected three of the winch hoists that were used to haul up bulkheads thorough the spoke tubes. Back through the two sets of airlocks, and he used more tie-downs to fasten the winches to the hub and each of their winch cables to the flanges that had held the nose fairing during the lift up her through the air. Thanking the urge of designers for standardization of connectors, he was able to find power outlets for the three electric winch motors. Opening the outer airlock door inward, he toggled the power of the three winch motors until one part of the 40 meter long tube bumped against the port area, then he carefully toggled the remaining winch motors, pivoting the huge tube slowly around, against the docking port, hoping the inertial mass would not tear out the initial contact winch tiedowns. The lash-up held, the tube was held to the docking port. But Improy was captive inside. He told Catalie to get in her worksuit quickly, and de-pressurize the whole section, fast! Then open the inner airlock hatch, let him in, then close the two airlock hatches and tell ground control to fire the docking latch assembly. He scrambled into the open inner hatch, swung it closed again, began the pressurization of the section. By the time it was up to pressure, the docking was activated, and the outer airlock was opening. Then the inner opened, and they looked in to see a bunch of wide-eyed sweating half asphyxiated people, who wasted no time getting loose from seat belts and straggled tumbling in free-fall into the Embarcadero.

Chapter 6 A loose bulkhead makes a hole in one

That first space bus load of brave people took up occupancy of the 60 degree segment of the wheel, as versatile a bunch as they were courageous. Each had been trained to do three job functions, including the initial setup of the prefab habitat's related inbuilt mechanisms which had been built into the two meter deep walls, floors and ceiling. A two meter transportation corridor went completely around the wheel. That left over a 4 meter space for each special function facility, such as the kitchen restaurant and commercial shop areas, which were included in this first habitable area. The 838 meter long 60 degree arc, 4 meters wide, made for 3,300 square meters of working floor space. The residences were sprinkled all through the facilities, in amongst the shops and light industrial sections. Only the two areas intended for agriculture were lacking in residences, because it was less shielded from incoming solar energies. Normally there would be living space for 250 people maximum in this first habitable section, each person had personal space 2 meters wide along the corridor, was 4 meters deep and 4 meters high, so each was built as a loft-augmented living space. Couples had adjoining areas and were able to remove much of the adjoining wall, creating a room 4 meters by 4 meters.

Improy and Catalie had taken up one such double room, the residence nearest the airlock into the area in which they continued their work of removing bulkheads and de-gassing habitat segments. The 33 new people had their pick, at least temporarily, of the remaining 248 living quarters. Most of them clustered near each other, an unconscious reaction to the really unnatural world they were now in, a small fragment of

the teeming population for which it was designed and built. All of them had participated in the debugging of this area when the wheel of habitat segments was assembled on the New Mexico desert floor before launches, so it was not that strange in some ways; but that the gravity was so small compared to what had been there during the test habitation, it was a weird change to the otherwise familiar. And, there was some coriolis curvature of the path of falling objects and poured liquids. That curvature would become more apparent when the wheel was spun up to full speed to simulate Earth surface gravity.

For now the rotation rate only provided 1/5 g, to make the job of hauling bulkheads out much easier. Yet, work was still dangerous. Just as Improy had gotten one of the bulkheads to the hub end of a spoke shaft, the attachment point of the winch cable, overworked during its emergency earlier use during the rescue of the space bus module, gave out, and down the bulkhead went through the shaft, building up speed, bouncing against the inner channel of the spoke as it went. risk of that happening was why Catalie always took a different path to the hub to meet her partner for the placement of the bulkhead outside the hub. There was a bottom, of course, and the heavy bulkhead had spun to an edge on orientation when it hit the floor, slicing through the flooring, service channels under the floor, through the module's outer shell, and out into space, gone. The two aluminum circumferential bands were undamaged, but the central glass one had been severed. The work area was still exposed to hard vacuum inside, so there was no venting of atmosphere.

But, there was this big hole.

Some of their propellant allocated for the full spin-up had to be spent instead to de-spin the huge

wheel, for there was no way to do work of this magnitude on the outer shell while it was spinning. Their choices were to pull the whole habitat module, replacing it with another launched up to replace it from the ground; or to patch the damaged one. Since it was one of the six which were built for attachment of a spoke to it, there were no spares on the ground, so one would have to be built from scratch and launched up; it would take months to do. Neither option looked desirable. A patch job was looking better all the time to them, despite the need to fix all the service tubing in floor and ceiling, and splice the fiberglass cable around the outside. And to seal the hole itself, at least as strong as new.

Since the damaged site was not in the one which was equipped for light industrial use, they decided to extend the habitable area to include it, since the machine shop area was adjacent to the 60 degree section now occupied. That would make it a lot easier to make the pieces needed to do the repair, although the facility was designed for use in artificial gravity. They gathered the new staff members who had any machine shop or even hand tool aptitude, moved them into the newly activated section of the wheel's interior. The accountant was pressed into service there, to keep track of all the spares that were used from the original launched storage cabinet areas, were recorded and sent to ground for sending up a stash in the next space bus launch.

But there was not going to be such a launch for awhile, as they had not found a way to prevent the problem that happened with the docking of the original one. How do you convert people into rigid objects anchored to the spacecraft? That meant that instead, the steering thrusters for the docking had to be modified to enable a mode of much smaller thrust. That

would take a longer time to dock, but ought to work. Meanwhile there was a sudden scarcity of people volunteering for the next ride up, having watched while the first bus load almost was doomed to a fiery re-entry, and they did not have confidence that Ownma Corporation considered the workers much differently than the launch vehicle: expendable, easily replaceable property.

Since they had to send up a replacement fiberglass circumferential cable anyway, the severed one not being repairable with sufficient strength using the facilities on hand up there, the decision was made to modify the docking thrusters to have half the original thrust per pulse, and to send up a dozen agricultural section workers, along with small livestock consisting of breeding pairs of quail and fish, and feed enough to last until locally grown feed would be expected available. This would give the agricultural workers something to practice on, and would provide some real home grown food, besides grain and vegetables, for the personnel there if all went as planned. Shipping food up there was quite inefficient. The Corporation paid for huge insurance policies for the benefit of the agricultural workers, and gave bonuses on the spot.

The standard configuration vehicle was set up on the launch pad, tug booster flyback module on the bottom, the habitat module as modified to be a space bus on top of that, and a sleek airbreather booster strapped on the module, and up it went.

In the Embarcadero as they called it, the airlock dock facility, Improv and Catalie waited, already partly in their space environment worksuits. The space bus module hove into view, began to nuzzle up to the docking ring, the slower steering thrusters and modified feedback loop worked. Soon there were a dozen more

relieved-looking members of their population, along with crates of seed and fish and quail, all needing homes soon.

Chapter 7 Back to zero-gee for repairs

A real Stanford Torus space settlement for 10 times as many people, built somewhere further up and so far out of the protection of the Van Allen belts, would orient its plane of rotation to maximally use its mass to shield from solar storm particles, and get agricultural sunlight in by way of a sloped optical mirror surface; but here in the somewhat radiation-protected Low Earth Orbit, given as simple a design as possible, the orientation was to let the sunshine in through shuttered windowed panels along one side of each agricultural section. The louvered shutters could then be adjusted inside the windows, to control and re-direct the incoming sunlight energy for the growing plants.

That was the first problem they found: the sunlight came in horizontally with reference to the ground level formed by the centrifugal force of the spinning wheel-shaped habitat. The plants closest to the window got the most sunlight, shading the ones behind them. This had not been found during the test period when operating on the ground before launch, since the Sun did its normal arc over the sky as it has always done there. But up here, the Sun was essentially motionless, sunlight coming in from the side wall window areas. Like houseplants in the windows of homes on the ground receiving morning or evening sunshine, the plants up in the wheel habitat grew to an orientation tipped over, toward the motionless light source to the side. This effect was discovered when activating one of the agricultural segments, even while the wheel was in the non-rotating mode for now, while repairs were being made.

So while sections were cut out of the original space bus casing, they also cut some strips of habitat

tank casing to be used as terracing walls, and brought it into the remaining, still open to hard vacuum, section built to serve agricultural purposes. They brought in twice as many strips as would be needed there, intending to use it in both agricultural sections, once the whole wheel was pressurized.

Outside the huge, now-motionless wheel, Improy and Catalie in their space worksuits cut a patch panel for sealing and strengthening the exterior wall where the ragged gap had been torn by the exiting edge-on bulkhead. Deciding that it would be easier to do some of the interior repairs from the outside, they cut away the jagged area of the hole, big enough to enter and work in there. At that point they decided to also melt the original but severed fiberglass security cable, to be replaced by the new whole cable brought up with the agricultural shipment, back together so as to still be able to encircle the perimeter of the wheel, but would be loosely anchored to the shell, and so would be usable as an overhead cable from which to hang and ride along so as to be able to travel around the wheel's outside even when spinning full speed. That would enable some repairs and inspections, not to mention a bit of an amusement thrill ride. A cable was dangled from near the hub airlock to tie to this added perimeter cable to access it, but also they used the opportunity to use the two doorframed hatches from the two spent space buss modules to make the double doors of a new airlock there, to go direct out to access the outside even when spinning.

When they had the service plumbing pipes and utilities repaired in the below-floor part of the damaged area, and the new airlock built, they sealed the new section on the outside to cover the exterior hole up. Then they repeated the placement of the fiberglass cable around the perimeter of the wheel, using the new

cable. They also secured the "cablecar cable" loosely around, using newly placed hangars spaced around the wheel.

Finishing this as quickly as possible, to minimize the distress to their new companions in space including fish and quail, wearily they went through the hub airlock, disassembled their worksuits from around themselves, advised everyone to take up positions near what would become the floor, and they once again fired the reaction motors mounted on the outside of the wheel, and it again spun up to partial gravity, to the 1/5-g as before. They had yet to complete removing all the bulkheads, along with the venting of any remaining propellant trapped in those sections, so the lower centrifugal force was still needed. Besides, they only had enough remaining propellant to eventually spin up to 3/5-g, anyway. Someday re-supply of rotation motor propellant would be allocated and sent up; but that would not happen for some time. A quick tour of the machine shop and agricultural area to assure that everyone was more or less secured with having a bit of gravity orientation, the pair were soon fast asleep in their quarters, a well earned long rest.

The agricultural workers were getting their first practice in the moonwalk-like gravity locomotion movement. Water in the fish tanks again had a top surface, bubbles would now rise, making aeration of the water easier, although still slow motion. Being mostly ground birds, the quail's stress levels clearly were going down too, with there finally being a "down" and a ground surface. They built a small terraced section from raw materials stored in the original supply section of the machine shop, and planted a few seeds along them, a head start. Their mission profile had not expected such an extended duration without full 1-g artificial gravity, so it was not known what seedlings would do at 1/5-g; but

they were going to find out soon. They also began a manual routine of opening and closing the louvered shutters so as to provide a simulated day-night cycle for any circadian rhythms that might be happening in the agricultural area. Eventually they would find what could be grown productively in endless, high intensity sunlight; but for now, the directive was to simulate as near as earth-normal conditions as possible.

The next morning, the task of removing bulkheads was resumed, a long and tedious task, still as risky as before. They had learned to examine the winch cable end connections, putting that on each day's checklist. Then the routine began again: crack the bulkhead bolts, wait until most of whatever gas pressure remained inside had vented out down past them, down the corridor and spokes and out into space. Then finish removing bulkhead bolts; haul the bulkhead down the corridor to nearest spoke shaft, winch up the shaft, take it outside the hub and lash it to the outside of the hub. Return to the freshly opened module section, open each bin or storage section to verify no remaining propellant in there. Then go down to the next bulkhead, and do it all over again. Boring, routine; but no time for not paying attention to what they were doing. Memory of the effort expended because of the broken winch cable and errant bulkhead. And that bulkhead was somewhere out there in space, not something a spacecraft would survive if hitting it. Luckily space was very much bigger than the bulkhead, so chances of missing it were quite favorable. But not 100%. There was a lot of "space debris" left over from earlier space launches by many nations. Adding to the hazard was not something to be done if at all possible. So they slowed down that dull and routine task just a little, to pay a little more attention to each step. It was not just winch cable breakage that could cause calamity.

Each newly opened module was something to be explored a bit, a minor diversion from the routine. They had already opened up at least one of every module configuration, so it was not that new. Each of these modules had been built down on Earth, assembled into a wheel shape, been occupied by a teeming population of a thousand busy people out in the New Mexico desert summertime; then each module was disconnected, bulkheads installed, hauled to the launch pad, set vertically on top of the engine tug flyback module, filled with extremely cold liquids, booster airbreather latched on, then jammed hard upward by the engines, juggled this way and that to orient to end up on target to dock with the previous members, then docked to the one which had arrived before it, then waited there in the space environment until another module came up and docket at its other end. And now the people were pulling bulkheads off of it. The internal configuration of each module, installed equipment, and stored materials had all been selected to survive the freezing of cold fuel, launch shocks, and exposure to hard vacuum.

Or at least that had been the intention. Occasionally they would come across something that had been put in place during the debugging process, getting all the systems to cooperate together. Not all of these got documented and removed for later re-installation, and upon opening the module up, shattered remains of things like rubber balls that had been frozen in liquid oxygen then launch vibration had squeezed it shattering it into many pieces, which had to be cleaned up.

Eventually, they finally came full circle, around the wheel to the bulkhead which had pressurized occupied living space on the other side of it, which had been their first cleared area. So they went up to the

airlock on the other end of the hub, and closed it, then closed all the emergency airlocks remaining in the areas of the wheel that were still not pressurized. One at a time, they released the compartment's stored air from the tanks sent up with each prefab module, until it was up to pressure. In a few more hours, the entire wheel with its spokes and hub, were all pressurized; and temperature within occupancy range; the air cleaners declared the air was pure enough. So they removed the bolts from the last bulkhead, and took it to the machine shop for raw material for fabrication, as it would be difficult and wasteful of effort to take it outside and lash it down with the other some 400 bulkheads stored out there.

It was celebration time. All 47 of them gathered in the restaurant-kitchen area, and the chef prepared the fanciest meal she could with the limited foodstuffs on hand. Wine was dispensed from the plastic shipping bags, and a toast was given for all their achievements. Lively music from the vast music library onboard was played a bit loud, and with the help of the wine they learned how to dance in 1/5-g, partying for hours until spent they went to their quarters, weary but in a good mood.

They all took the next day off, vacationing except for minimal monitoring duties. It was back to work the next day, and Improy and Catalie were again partially suited up in the hub's Embarcadero, ready to receive or rescue another space bus load of 33 people, a full test of the modified docking thruster settings and feedback control values. This time, immediate variation in the feedback parameters would be done by Catalie as she watched the realities of what the docking progress was doing each instant. The people inside were only wearing seat belts and shoulder straps, and so was the same risk of phase shifting from internal resonances

situation that had nearly cost the lives of the first bus load.

As Catalie watched on the camera monitoring screen, the newly arrived module accurately targeted the docking assembly, within the allowable alignment parameters. Contact was made, triggering the docking clamps to latch, she did not have to do anything. Opening the airlock, Improy went in to greet the new arrivals; the hub door closed and sealed, then the outer door opened inward, then the door was opened into the space bus. All seemed calm so he had Catalie open the inner hatch, and soon the new crew members were entering their new home, 33 more people, mostly couples.

Down on the ground, the "space bus" modules were being built as fast as possible, now that a proven design existed, at a rate of three a week. So that set the rate of population increase for the next couple of months, about 100 new arrivals per week.

A launch of fuel for the spin reaction motors was delivered, and was something new for Improy and Catalie. The fuel supply module arrived and docked, but then instead of passengers, Improy suited up and went out to connect the transfer lines of the two liquids, and pumped the propellants through the tubing, down one of the spokes utility channels, and into the fuel storage tanks near the reaction motors. The emptied module was lashed as the other spent modules, a large supply of raw material had accumulated outside the end of the hub, and this new one joined the collection of spent space bus modules.

Finally it was time to go for full artificial gravity. Everybody was alerted to find a stable place, backs toward a support surface, although the actual

acceleration was not all that great; the mass of the wheel was huge. The agricultural workers monitored the water sloshing in the fish tanks, and the antics of the quail as their world started doing something weird again. Eventually a full 1-g was achieved at floor level, which felt quite sluggish after acclimating to the 1/5-g for so many weeks.

The quail seemed quite puzzled about it all for awhile, but soon their legs regained strength, and coordination was back as before. The two agricultural segments were terraced with the strips cut from the first modules and stored in the second agricultural module; a full set of seeds was planted. Soon, quail eggs were produced, and put into incubators; the quail as yet were not comfortable enough to hatch them themselves, but in time it was hoped they would do so. Meanwhile, incubators and brooder equipment was put into use, to expand the quail population to match the expected grain harvest soon to appear, in the very plentiful sunlight which was always bright like high noon and never a rain cloud to interfere.

Chapter 8 Prepare to be doubled in size but it is not yours

Improy and Catalie were out riding on their "bicycle built for two," which they had had built in the machine shop for machinists' practice in the new environment; the wheel rims were overhead instead of below them, however, as they were hanging from the fiberglass rope around the outer perimeter of the giant space station wheel, the spectacular universe getting seen in its entirety a dozen times during one full circle trip around to their starting point as they pedaled. Enjoying this outside sport, they were radioed that Ownma management was on screen in the control room, demanding to talk to them. Since it took 30 minutes to climb back up the half mile to the hub airlock to get back in the normal way, they elected to go through the special airlock they had installed where the hole had been made by the out-of-control bulkhead months before. Ownma management seemed to have an uncanny sense of the most inconvenient time to make their demands, and this time was no exception. They would have to return to their bicycle by the same route, but no matter; more adventure. Even this time was going to be a bit scary.

Stopping their bicycle below the outer hatch, Improy accessed the control panel so as to have the internal air pumped down to 1/4 atmosphere, saving some of the precious gas. But they were in a hurry, so they vented the remainder into space, then he had to stretch from the bicycle pedal base to operate the airlock hatch, swinging it up inside. At this point he had to briefly unhook his safety tether clip, stretch up again to hook it again on the internal safety hook. Catalie handed him her safety tether clip too, he connected it then he had to pull himself up into the hatch. The

outward centrifugal force was slightly greater than 1-g there, so it was like being suspended from a high ledge and having to pull oneself up and get up onto the ledge. He helped Catalie similarly scramble up into the hatch, the immense universe was where falling would go to, a very long ways "down" to their senses. They closed the outer hatch, let air into their chamber, opened the inner hatch, and hurried down to the control center, still in their space worksuits, helmets tilted back.

This time, it was Theo's face onscreen, whose form of egomania at least was rooted in the theoretical foundations of things. "We are going to build a second wheel next to yours, with a connected hub bearing assembly joining your wheel with the new one. The direction of rotation of the new wheel will be opposite yours, and so the combined hub shaft assembly must accommodate the gyroscopic torque forces when the combined wheels have their orientation changed in space. Soon the hub bearing assembly will arrive there, and you will have to figure out how to very securely attach it to your airlock on the shaded end of your hub. The next modules docked up there will be the six spokes, and then the modules will be brought up to form the second wheel's ring. All that will get done without human help up there, just as your wheel was first built up there without human presence there. Once you have the new secondary hub connected through the bearing assembly, the hub modules will arrive for you to attach to yours through the bearing. Then the next shipment to you will include a new pair of space worksuits and pair of people who you will train to do your job, but over in the new wheel." The screen went blank, no chance to ask questions. Ownma management did not consider employees as capable of asking worthy questions, so why would they allow time for questions?

"At least we won't get stuck with doing hundreds more of the bulkhead removal processes," Improy muttered. Catalie's thoughts were off in a different direction: "Why didn't they tell us that another wheel was to be part of this facility? Sure, that kind of design has long been envisioned, so as to be able to spin up and back down, by torquing at their hub bearing instead of expending reaction engine propellant mass to get spinning. It would have been a lot easier to have built the hub assembly that way right from the start." Improy replied that one thing that Ownma management did well was to plan far ahead; but they also played their cards close to their chest, as the saying goes. "This must be a new project direction; or else they did not expect us to succeed at this task so it would have ceased long ago if we had failed." Catalie went on, "How will the added wheel receive sunlight for its agriculture? Either all agriculture will have to be done in our Sun-facing wheel, or the whole pair of wheels will have to be kept in a slanted orientation, so that some sunlight will come in past the edge of our wheel, for partial sunlight each revolution. What a crazymaker to plants, to have the sunlight come in sweeping rapidly from a steep angle during 20 seconds, then going into total darkness for 40 seconds until the next 20 seconds of intense sunlight. Will they adapt?" Improy replied that the livestock will have to be provided artificial lighting, powered indirectly by solar cell panels sticking out so as to not be shaded by our wheel, not very efficient use of their solar energy resource.

Relaxing after dinner that evening, Catalie went on as if the conversation had not been interrupted, "If they had just wanted to be able to spin up and down by pushing against an opposite wheel, much smaller mass could have been used at each airlock site, and just spun up much faster, to the equivalent reaction. So they must have other purposes in mind."

That their guesses were almost entirely wrong became clear when they received the construction plans. Both wheels would be mirror images of each other, including the incoming of sunlight through the side panels of one side. Both wheels would be fitted with a huge flat mirror at a 45 degree angle to the wheel. That meant that the whole dual wheel would have to be edge-on toward the Sun, and the two mirrors sticking out from each hub would have to be de-spun constantly to be motionless reference to the direction of the Sun. It still would take reaction motor propellant mass to make up for losses in bearing friction, unless they could use nearly frictionless maglev bearings there instead of roller bearings. Why go to all that trouble? One wheel was surely enough to research out the interactions of all the kinds of machine and living systems.

Catalie began to have suspicions that Ownma Corporation was going to move them somewhere else; but where, and why? There were a bunch of places that came to mind. "Where do you think we might be getting sent to, in our small city of a double wheel, Improy?" she asked out loud.

He looked startled for a moment, a far away look in his eyes. Then replied that nowhere that would not need more shielding than was economical to ship up here by reaction engine powered vehicles. "GEO would be the lowest energy boost. Then there would be the Lagrange points L4 or L5, at the distance of the Moon. And then there was the possibility they were going to be sent to orbit Mars, no turning back. None of those destinations had any benefit he could see for Ownma Corporation. And without shielding ... wait, what if all those spent space busses were placed between the edge of the wheels and the major source of solar particle radiation? And, edge-on, part of every rotation

would be shielded by the rest of the wheel's mass, further reducing average exposure. Yet, cosmic radiation comes from all directions." Her reply was that she wondered if their daughter Idealiana would continue to chat with them everyday via the internet if they went to Mars, the round trip transmission delay becoming a real slowdown to chatting. "Maybe they would send us to L-1, the balance point between the Earth and Moon, and anchor our dual wheel city to the Moon for stability, since only a fiberglass cable's strength would be needed for that." Actually, would maybe risk using the wheel's mass as a counterweight to hold the tether up, an unacceptable risk to the city, in her opinion. "Maybe they just want to get our huge mass so far away it will never possibly come down as a meteor to the ground."

With such thoughts, they drifted off to sleep, in well earned snuggling restfulness.

Chapter 9 Receiving a hub extension for the space station

The odd-looking module hove into view, aimed at the shady side's airlock docking port. It did the usual pop off of the nose fairing and reel in to the front of the engine tug module, yet the docking end of the module had an odd ring around it, a meter from the vacant-looking docking end. It hung there as if poised for docking, on their viewscreen. "OK, there it is, let's lock our helmets down and head out" Improy said, heading toward the shaded side airlock. They exited out to view it in person a moment, then moved their security tethers to fasten outside the hub, a few meters from the airlock's opening. "OK, we are clear, close the airlock" he spoke into the microphone radio link to the now-acting port supervisor. Seeing the hatch swing closed, he spoke again, requesting that Ownma White Sands Control Center resume the motion of the new module. A bit apprehensively they watched and waited. The big engine tug module would normally have long ago disengaged from the module and headed back toward ground. Instead, they could see a blur at the rear of the engines, and the huge module headed square at the end of their hub module. Wham! They almost lost their grip on the handholds, as the shock reverberated in their module's structure, quickly damping down. They then began to inspect the impact joint, it appeared to have seated well around the outer edge of the end of the module. Giving the OK to disengage, he saw the huge engine tug glideback module release its hold on the far end of the module, and began its de-orbit sequence, was soon out of sight, going back to get another module to help bring up in a few days.

Their instructions were unusual even more. They then took sledgehammers and went around the

perimeter of the joint, driving in large threaded nails that had been provided partially pre-embedded in the newly arrived module's nose fairing. Next they ambled along the safety rope along the hub's exterior, and entered their own hub by the usual sunny side airlock hatch. Inside, they left their suits on, again going out but this time through the shady side airlock. They connected the power connector, lighting up the cylindrical space there, to the tank bulkhead down a ways. They used a caulk gun to seal around the joint's perimeter, then used a ratchet wrench to secure a locking nut on the protruding ends of the threaded nails they had driven in from the outside; then more sealant on each of those places. They went down the cylinder to get a look at the huge odd ring mechanism there; then they went back inside and had lunch together in one of the cafeterias.

Between munches on a sandwich, Catalie read the instructions outloud to Improy, as he was eating a two-fisted grip huge quailburger. "Next we go back out to the far end of the new hub module, open the airlock there and go inside, de-gassing the interior and taking out the internal bulkhead, go activate the remaining airlock in there. Then we remove the locking sleeve from around the bearing inner perimeter, and inspect the clearance, needs to be between 0.05 and 0.1 cm all the way around. Plug in the power to its control box, and start its temperature control system, along with the beginning of current input to its superconductor magnet rings. We monitor the progress of this from our normal control station for the next few days, and if it all looks stabilized by then," pausing to munch her sandwich, "we go outside the hub, remove the outer shield sleeve, and give it a shove to see if the module begins to rotate slowly. And we will occasionally monitor its angular velocity for the next few days to see if it is adequately frictionless."

Chapter 10 A plague is loose inside and there is no way out

The next day they went out to inspect the new hub and its immense 10 meter diameter magnetic levitation superconducting bearing. They had started it rotating the previous afternoon, and it was still rotating, and sensors measured only a loss of 0.001%. So it was off to an effective start. What it would do when it coped with the combined masses of two mile-diameter wheels twisting on each other at times, was yet to be determined.

They went into the center of the new hub, and inspected the six bulkheads that they needed to remove now, preparing for the arrival of the new wheel's six spoke module sets. It would be interesting to see how the hub's bearing responds to the additions of unbalanced motionless masses, as the new wheel's habitat modules were robotically built up by the teleoperated dockings. Their role would be merely to observe, not participate in, the assembly of the new wheel. No one had been present when their own wheel was built up by such teleoperated dockings, and none were expected needed for the new one. If and when they needed to use their shaded side airlock, they would have to pass through the cleared hub module to the far end of the newly added hub's airlock's open hatches, was all. The six holes into space were created by their removal of the bulkheads; they stopped the rotation of the new hub, activated the small feedback loop motor that would keep the hub motionless for the easier docking of the spoke modules.

They thought of volunteering to take out the bulkheads from the upcoming modules as they were docked, but decided to wait and see if they were

directed to do that. Ownma Corporation really ought to send up another pair of space adept workers along with more space worksuits anyway.

Returning indoors, Catalie chatted with Idealiana via the internet chat system, while Improy checked through the latest directives from Ownma White Sands. When they got back together over lunch, Catalie reported that Idealiana's tenth birthday was going to be spent in Girl Scouts summer camp in the mountains. Improy reported that any new space worksuits would have to be made up here, since the facilities that had built the two they now used, had long been scrapped. They had found documentation for their manufacture, however, and had forwarded a copy up to them. There were some things that the station's shop could make right away, but the specialized fabrics and flexible joint materials and fabrication technology was going to have to be developed from scratch. It made sense to have their own fabrication capability for spacesuits up here where they were needed; but some foresight ought to have been prepared for that eventual capability need's fulfillment. He would try to recommend a change in the new module equipping for that, but Ownma did not have any real way to process ideas and recommendations that were unsolicited from non-management employees.

It was like the Suggestion Box on the wall in employee sections of Earth-ground corporations, where the suggestion forms put into the slot in the suggestion box merely slid down into a wall chute down into the basement's trash dumpster; the intent merely to make employees think they were smart enough to think of an idea on their own, and thus work harder, even though Management personnel were clearly the only real smart ones.

Maintenance of social stratification was key to sustaining the wealth of those inclined to be bullies, and egos were honored supreme, as part of that game.

Having space worksuits made, was obviously not currently part of Ownma management endless partying, at the moment. So Improy asked Catalie to set up the requirements for facilities for long term manufacture and maintenance of space worksuits. She replied, after a sip of coffee, that they could start with testing the use of emptied food containers of all kinds, along with finding out what duct tape would do when exposed to the space environment, holding such containers together. And send down a requisition for bolts of the special fabrics that might be adaptable for the suits, along with specs for fabrication of the fabric's industrial equipment. How about the complete infrastructure for making and forming materials like Kevlar and Teflon, could they get them from the ground? Improy muttered that he would send requisitions, while he was distracted by the thought of having to patch his space worksuit with duct tape and tin cans, looking like the Tin Man in the Wizard of Oz story, while he was trying to perform an emergency space rescue.

Just before they got up from the lunch table, he noticed that there were only about half as many people there in the cafeteria as usual about this time. So, back at the Coordination Center, he checked into what was happening, and found that many of the station personnel were still in their quarters, had not showed up for work that day; a huge increase in people on sick leave.

The station's doctor, his wife, and the nurse were all among the ones on sick leave, Catalie found. She chatted with the doctor, one of his many callers of the

moment; he said it seemed to be a rapidly spreading flu epidemic, and was also spreading down on the Earth's surface. Apparently some of the latest space bus load of people arriving brought beginnings of the illness with them, unknowingly. And the epidemic was looking real scary down there on the ground; they had no suggestions for use in the space settlement's version of the problem.

Call back in a few weeks, they had told him, might know more then. And so their station doctor said that for now everybody was on their own, and even he was down and out at the moment, could not help anybody else, although he was trying things out on himself to see if any of their medications on hand would help. Aspirin made it worse, was all he had found so far. He thought that might be because the normally small internal bleeding aspirin causes, might be letting the pathogens into the bloodstream through those small lesions past the protective lining of the stomach.

Catalie did a check of the current population roster, found that indeed all of the latest space busload were out sick, and the people they had contact with since arriving were also more likely to be out sick today. She tuned into the web newscasts from the international news sites, and found that it was top news all around the world. The 1918 epidemic was nothing compared to what was happening now. More ominously, a few of the normal web news sites had not even published today, presumably because of lack of staff to prepare it. Even though much was done in home offices these days, they were not able to do the work in their own homes, so they must be real sick for that to happen.

She noted that the epidemic was spreading less rapidly in Asia and Mexico, but was just as severe an

illness where it did strike there. Researchers were sharing data worldwide, which she followed as much as possible.

Improy called her and asked for help outside, there was a new kind of vehicle arriving. Out in their space worksuits, they found the unmanned vehicle was already hovering near the airlock, its nose cone swung out for docking access. It appeared to be a module that was permanently part of its tug booster engine module, and it itself had airfoils on it, and it was all covered with re-entry tiles. It was the first of a modification that was entirely re-usable, for delivering supplies without having to leave behind the 40 meter long 10 meter diameter fuselage each trip. This would make re-supply much cheaper, an entirely reusable launch system that would not require extensive refurbishing between trips, or so it was hoped. They would see how this one survived its trip back home. Meantime, they had to manually unload its contents. Going back into the airlock, they requested ground control to resume docking. They were not sure why it had not actually docked on arrival, but it had given them a chance to look it over first.

No response from ground control. Bad sign. So they pulled the vehicle into alignment with the docking port; Improy stayed to watch so that it did not drift out of alignment while Catalie went down to the far end of the new hub section to re-enter the station. She activated the emergency docking mechanism sequence; then, joined by Improy, they opened the airlock hatches and began hauling the shipment into the hub area, loosely floating around secured by netting for now. They had to hurry, and get the vehicle loose, as that was the only real access for space busses or anything that remained, now that the new hub assembly was using up the other airlock dock. Finally they released the vehicle, and for now lashed it to the outside of the hub

cylinder, added to the huge array of old space busses and supply modules already lashed there.

Dinnertime and they were comparing notes, Improy had not been able to find anyone to help haul the new supplies down to the wheel rim storage, so he had moved a few containers, called it quits for the workday. She was following the medical crisis, and news was that the pathogen seemed to be caused by a sharing of genes between the Cytochalasin B immune-lowering fungus found in pasta, and an influenza virus. So it was being spread both by way of airborne and food vectors. They had been spending most of their time recently in their worksuits, and did not eat pasta, so for now were spared the illness. She had to prepare this dinner herself since the cafeteria was not open, the cook and other workers there all were too sick to operate the eatery.

By the next day, they were the only able-bodied people in the station; and they could not run it by themselves. And sharing the same air with the others, eventually there would be some spores that would get past the air filtration system and they would be sick too. The facility's medical staff no longer answered their calls. "We are going to have to play doctor ourselves" Catalie commented over breakfast, examining the latest reports on the terminal there. "What can you and I do that the rest of the world has not done, that would fix this mess?" complained Improy. She replied that one thing to their advantage is that they knew what did not work. It acted like a bad case of the flu, but one in which the person did not get better at the normal rate. Therefore was likely the fungus immune suppressor was the cause of its lingering nature. Improy remembered some experiments in electrohealing which had attracted his attention even though it was not an

approved medical thing. He hurried over to his closet and brought out a signal generator, and got on the computer terminal. "Those early experiments came up with a Cytochalasin B frequency of 77 KHz frequency followed by a 91 KHz frequency, and the signal was applied through metallic conductors held in the hands, covered with wet paper towel material for a few minutes." Soon he had wired himself up and had applied those signals to himself, pointing out to the dubious Catalia that the 10 volt signal could not even be felt. She was quick to repeat the signals on herself. But they had not been sick before, so all this test had indicated was that it did not hurt them. "There are a bunch of signal frequencies to destroy flu pathogens too, but they mutate fast and so is unlikely they are easily found," he continued. Let's see if we can find anyone who is willing to hold these electrodes for a few minutes.

By evening time they had gotten 45 people to do the electrode thing for ten minutes each. There were over twice that many yet to try it. The doctor would not try it, he just lay there in weak misery like the others. The next morning they went around to see if the same people were interested in repeating the electrode thing, and found that each of the ones who had tried it earlier had been even more sick in the night, but drinking a lot of water, they were now actually feeling better, and seemed to be in a normal recovery from the flu. All of them were eager to try it again. Improy had them do a third signal, an offset pulse waveform of 30KHz for ten minutes, which he had read was a general helping signal, according to the same research data. The next morning the 47 of them were up and around, the only ones in the station doing so. Catalie went to the station doctor, advised him of the happenings; and he weakly held his hands up a little as if to hold the electrodes, so they applied the three signals to him.

Catalie made a direct call to Idealiana, down on the ground, at Girl Scout camp in the mountains. They were unaware in the mountain camp that there was a crisis worldwide rapidly going on; she would ask the camp cook to not make the sphaghetti for dinner after all. Catalie said it looked like a little electrical gadget might be very helpful; Idealiana reminded her Mom that Girl Scouts no longer just learn how to start a fire by rubbing sticks together, but also such things as how to do some machine shop and simple electronic design and construction. So Improy got on the connection, sent the electrical gadget's schematic and usage tips so far found, and Idealiana signed off and headed for the log cabin where hand tools and electronic hobbyist stuff was kept. Catalie and Improy collapsed into bed, what a hard day and what would tomorrow bring?

In the middle of the night, there was a weak knock on their door. They were surprised to find the doctor there, using a walker; he asked to be given the signal generator and shown how to use it, immediately. Breakfast the next morning, they discovered that there were some emails from the doctor, as well as from those who had originally agreed to try the electrodes; with their help, the signals were being applied to everyone on the station. And the doctor advised his colleagues down on the ground of what had been discovered, that seemed to be helping a lot up here. He was advised that although people were not dying down there of the illness immediately, that they were perishing from lack of care, no one was left strong enough to care for the others, even to provide water. The few doctors still online began to search for the resources to generate the three signals. Then there was communication silence.

By the time a week had passed, all the station's

staff were up and about, although most were still weak. They all showed up for turns holding the electrodes once a day, and time to chat while doing so. It was like their coffee breaks before, but they called it their "healing breaktime." Some web news sites were coming back online, and the first messages out were descriptions of the required electrical equipment and its use, asking people to search these things out, or build them where the skills existed. There was a massive effort to get the equipment for use by everybody, but there was little still functional, without personnel that had not already gotten the electrical signal sequence at least once. Yet, things were on the upturn now.

Chapter 11 Don't expect Corporate thanks for saving them

Idealiana made a call up to them, saying that she was fine, that everyone in Girl Scout camp was fine, although some had started to get sick but had used the electrical signals to their hands, even though it seemed strange to them. She had built the basic 30KHz pulse generator, and had used a small computer to get it to run at the 77 and 91 KHz signals. Some of the other Girl Scouts had told their families over the internet chats about the electrical thing, and a few of their parents were building the gadget, already getting a bit sick; and then also more of the parents started arriving at the mountain camp to get to use the gadget that Idealiana had built and used, as word was out by then of the worldwide epidemic, and no pills or shots had been yet found to fix it. In fact, she and the other kids there had decided to not leave camp to go back home yet, as things were really bad elsewhere. Since there were no more computers adaptable to controlling the frequency settings, she and a few of the other Girl Scouts there built a bunch of single-frequency signal generators, which were used by folk who sat or stood in a line, someone calling out time of 7 minutes each, then each person passed the signal generators to the next person; keeping the same handholds until having done all three signals, discarding their wet paper towels, handing the conductive pipe handholds to someone else, done with it for the day.

Another thing that saved thousands of lives was that an old mountain man had remembered that several brands of old survival kits had contained an electrical thing whimsically called a "Zapper" that was part of a combined flashlight, radio and emergency signal transmitter and which was powered by a small hand

crank, which at least provided the 30KHz basic first aid part of the system, at one time had been considered as essential to remote emergency first aid as were aspirin and bandages. He directed people to the collapsing old site of a former Forest Service warehouse facility, where hundreds of the kits were to be found, thus eventually saving thousands more lives in the current widespread emergency.

"So it looks like we already have earned our keep" Improy commented to Catalie, "by finding out a way for saving millions of lives in the epidemic." Catalie replied a bit distractedly that the Ownma management personnel were taking credit for the healing technique, never mentioning them or that it had been first used up here. She continued "Ownma Corporation management people really do believe that all good ideas can only come from themselves, not from employees like us; and in fact much of management believes that ideas come out of thin air and therefore have no value." In fact, since all corporations like Ownma were based on sifting all communications between unsuspecting people, searching for anything usable for profit or power over people, Ownma Corporation routine snooping had snagged the messages Catalie had sent to her daughter about the electrical gadget, and later those from the station's doctor, and immediately had the devices built and distributed to corporate management personnel and their families, thus none of them perished. As usual, they did not keep records of where they had gotten the knowledge; they just made it theirs. Their belief in their superiority over employees was so stratified that it had been made into something like a religion, where they are taught that their corporate ancestral father was a great bull of a man, who declared that all his male decendants were chosen to own all that there was to be owned, causing all other people to fade away in destitute servitude, rightfully so

because he said so. How could anyone doubt it, since their obvious great wealth and power's luxurious living was there for all to see? Facts are facts, unquestionably. Therefore there was no need to give credit to anyone other than themselves, for anything. Including the idea for the unorthodox use of an electrical gadget to heal people during time of epidemic crisis. "Catalie, my love," Improy implored, "think of it this way. Ownma Management people have little to do in the way of work, except to monitor all our doings, including sifting through all the records of our conversations and all the recordings from the videomonitors which are everywhere. The little tidbits they find among the vast fields of our conversations and doings, is little different to them as it is to us when we wander in a field of wildflowers, picking the best for ourselves as if they belonged to us, and not to the flowers that bore them." "The Ownma Corp people have just as much brains as we do; they are just different in what they do with their brains" he went on, "It is what a person does with one's knowledge, is what makes the difference. We utilize out knowledge and skills to directly cope with the needs of life; but they have genes that predispose them to use their knowledge and skills to wrest the goodies away from others who created them, politely if possible, as usually they do to us nowadays. They have lots of isolated groups like us who actually create the things, and Ownma Management just uses what it gathers from us to augment what other groups do. And they are ever mildly assaulting each other, like the pecking order of older creatures' social systems work, which hones their abilities and inclinations to assault as a solution to everything. Those of us who show signs of being unhappy about that, have the DNA-resonant communication system targeted on them, so as to have a communications channel to find out the intentions of the person and to switch their focus at key junctures of

their life activiies, endlessly causing them extra weird struggles in daily life and thereby making them ineffective, thus no further problem to the Ownma Managers exclusive right to rule. They rationalize excuse for such subtle-level harrassment by fantasizing claims that their target person is a thief or child abuser or some other ugly motived person. So be careful, don't let them get the idea that you might be antagonistic to them, or they will put on the list for such hazing, too." Catalie just stared at him briefly. He went on "The effect on the target "blackballed" person is that the person trips himself up on and on, as if struggling with opposing purposes. Life seems to not be able to work out, and they appear a bit sedated, slower than normal. The hazing is kept up until the person is on their knees, no will remaining to oppose anymore. And it is all done remotely, the abusers out of sight; a clever technology originally designed for a somewhat more honorable purpose, that of behavior modification of persons with addictive disorders. But it works just as effectively and bafflingly on anybody they choose."

"You are just being bitter. Get used to the situation, and roll with the punches," he later said to Catalie, "That which is more useful is for us to go bring down the rest of that last shipment of supplies, and see what goodies Ownma sent us. It is likely the last supplies we will receive for a very long time." So they and a couple of the more recovered of their co-workers retrieved the containers from the net securing them in the free-fall of the hub area, and moved them down to the supply receiving area of the wheel's rim. Among the goodies was a small polymer casting, extrusion, and weaving facility, "I wonder if we can make fabric usable for space worksuits with this machine?" they said almost simultaneously. They headed out to find a couple of people who would become fine fabric makers, and they would all spend some time figuring out how

they could use this machine with what resources they had for making raw material for it, focusing on making material for space worksuits. Its extrusion capability also looked like it had potential for making spacesuit joints that would be far better than making them out of empty food containers.

They scavenged raw material from the cushions and seat belts from some of the one-way space bus modules that were lashed outside the station's hub. And some of those empty plastic food containers were beginning to look better for use in making spacesuit parts, once processed by the machine.

Among the containers in the last shipment were found one contaminated with a half dozen of small tan-colored cockroaches. "Wait, don't kill them!" Improy shouted, as one of the workpeople was about to squash them in revulsion. Staring in wonderment at the little beasties, Catalie added "Cockroaches can be raised cleanly in confinement, like snails are for Escargot; and they have a fine protein composition that could augment our nutrition, which is now limited to a few grains, vegetables, fish and quail."

"And cockroaches have a hard shell material which might be useful for making spacesuit material, who knows" Improy chimed in. "The cockroaches can be used to recycle much of our agricultural wastes, and they can be cooked and ground up for additive protein in our soups and quailburger."

Chapter 12 Surprise: you all were sent on a one-way trip

Cockroaches are experts in the activity of escaping and surviving in unappreciated co-habitation with people, was unfortunately re-discovered. Although as a source of nutrient proteins that supplied some missing ones from their interrupted supply of agricultural species, the little cockroaches also were experts at colonizing little nooks and crannies, of which the station had an abundance. Occasionally that would result in jams and failures of machines and electrical systems, so that they had to re-design and modify those areas that had been, or might become, handicapped by the busy presence of the little critters. On the whole, however, people grew fond of them to some extent, as they were a bit of increased life in the otherwise heartless behomoth machine in which they lived.

At breakfast one morning, Catalie was watching what appeared to be the same little brown German Cockroach that appeared every other day in front of them at the table, apparently attracted by the aroma of the food. It was a lone male, as indicated by the two appendages at its tail end. She and the little animal had taught each other that if she would place a small speck of her warm moist rice breakfast cereal in front of the critter, it would come over, tap it with its antennae, grasp it and pull it a few inches away from them, then munch it while Catalie and Improy finished their meal. It seemed to appreciate a drop of their beverage too, even coffee. Soon they would notice that the speck of food was gone, evidently dragged off to be finished the next day somewhere. A day or so later, their tiny visitor would re-appear in front of them at mealtime, not unlike

people showing up at mealtime in a cafeteria. Its presence was a little like a pet, something that both of them missed in their high technology living environment.

"I hope their population does not expand so much that we have to use insecticides on them," Improy commented. "All insecticides are neurotoxins to people too, and the buildup of such substances in our sealed environment is likely to deteriorate our mental functionality to the point of not being able to cope with the rigors of life up here. Then we would make some fatal goof, the end of all of us." Catalie replied that people had successfully struck a compromise balance with insects throughout civilization's history; neither had to exterminate each other. Where synergistic rationality prevailed, both kinds of species prospered better by the presence of the other. For example, think about our problem here with no honeybees available. The busy hundreds of perfect little pollinators that bees are, have to be replaced by people doing it by hand. And, we have no honey to sweeten things, either. I don't complain about the lack of mosquitos or ticks up here, however.

"You know," Improy mused out loud, "me in the protective shell of my spacesuit reminds me a lot of that little cockroach in its exoskeleton. I wonder if the designers of our space worksuits got the idea of putting the augmentation muscles attached to the outer shell of the spacesuit, from the insects' use of the outer shell as the rigid structure from which the muscles pull, that increases our strength when in the worksuit." She replied that it would not surprise her if that were so, since people often have gotten inspiration from nature's wonderful variety of mechanisms. Improy began calculating how many of those adult cockroaches would it take to get enough exoskeleton material for the

plastic casting and weaving machine to use to make an experimental torso shell for a space worksuit. A lot of them.

It had been half a year in which they had been on their own, following the epidemic down on the surface, when internet communication was suddenly restored to them. It was through one of the Asian links, apparently activated when equipment in general was brought back into operation. But the internet had its feelers into the whole world, even into the employee base of Ownma Corporation, which otherwise was in a zone of silence, including transmissions to the orbiting wheel station.

They eagerly looked for news of what had been happening down there, while they had struggled to cope up here. They found that in the epidemic, the megacorporations, like Ownma, had found a secret healing technique but were not sharing it with the rest of the world. The parts of the world where rice was the staple instead of wheat in pasta form, did not fail from sickness so rapidly as did the major part of the Ownma corporate employee base did, for example. Word of the electronic signal frequency set and way of applying it through handholds, eventually got out and so the Asian countries recovered first, and all the people recovered, not just the wealthy management types. And so, the internet link they were receiving was a lucky byproduct of that. The tremendous loss of life and general capability of non-management people in the Western world, had put the megacorporation Elitists in absolute control of the Western nations, a situation they greatly relished. The political situation was quite unlike anything the station personnel could even imagine. The plight of their families and friends down there was tragic, and there was nothing that could be done about it from up here.

Yet, corporate business depended on the servitude of the employees, so production capability was being brought back online, bit by bit. A mere 8 months after the epidemic, suddenly the wheel station got a command from Ownma Management, to ready themselves for arrival of the spokes for the secondary wheel. And in fact, as soon as two spokes were in place, that part of the wheel rim habitat modules would be arriving. As soon as that was in place, Improy was directed to pull the bulkheads and vent the area, then seal it , bringing it into a pressurized and habitable area immediately, and prepare for arrival of new one-way space busses of people for that area.

At first, only one a day arriving, Catalie watched on the exterior viewscreens, the teleoperated docking of module after module, first the ones for the first two spokes, then habitat modules which spanned those two spokes. Then the other spokes modules began to be sent up.

"That is really strange, they would build it up that way," Catalie remarked over dinner. "They seem totally focused on getting some space for people over there in the secondary wheel, while we only have 145 of our intended 1,000 people over here." Improy replied that it did not make sense at all, as they needed people desperately over in this wheel to have the space station functioning optimally.

They did as requested, pulling the bulkheads out so as to make the most rapid habitable area prepared in the secondary wheel station, including hub accesses. A space bus type module finally arrived, the first in a year and a half by then. Eager to greet their new friends, Improy was surprised to find armed men exit the space buss, followed by a bunch of people bound as their prisoners. The armed men commanded that

they be led to the new wheel segment, and instructed on how to live there.

When it was done, Improy was again having dinner with his wife, who was all ears about what was going on, so mysterious. With the appearance of someone who had been in shocked dismay too long, he related to her that the added wheel was being built as a prison for people given life sentences. This was a one-way trip for everybody here, not just for those prisoners, but their guards, and all the staff of the first wheel. No one was ever to come back. The megacorporations had determined it was far cheaper and secure to send prisoners up here to provide for their own survival on their own agriculture and industry, than to feed and house them in prisons down on the surface. And they would not need to worry about prisoner's escape. It was not unlike the ancient use of Australia, and of Alcatraz Island.

What bothered him the most, was that the majority of these prisoners given life sentences, were not actually bad people, but were only political prisoners, people who had led the rebellion of the employees against the megacorporate holdings, attempting to gain access to the mysterious healing technique during the epidemic's ravages of the non-management corporate personnel. The management Elitists had wanted the epidemic to so pound down the huge non-elitist population so severely that the remainder would never object to servitude again. But there had been an insurrection, easily put down by the well armed and healthy management elitists, and they wanted the leaders permanently put out of the way. Thus, the prison wheel in space.

Occasionally one of the two-way fully reusable cargo delivery vehicles would be sent up to dock with

the original wheel, resuming its supply. Then more of their station personnel arrived on one-way space busses as before. More skills were being added, so less improvising was needed to fill in for the missing work functions.

A few of these new people were auditors, whose functions were to document all the workings of the first wheel, and transmit it down to the Ownma Corporate staff. From there it was modified a bit then sent to the new wheel's prison staff, assigning prisoners to carry out specific equivalent job functions over on the added wheel. "We are being copied," Catalied exclaimed to Improy one day, "copied, but as life imprisoned people!" "Are you sure we too are not imprisoned people over here?" was his reply. "There are no return buses from here, even for us."

It took half a year to finish building the second wheel and to bring up its full population of prisoners and prison staff. Then, vehicles ceased to arrive. Ownma Corporation severed communication with the station, but the links to the internet through the Asian countries still remained. What they learned in the news thereby was that Ownma announced that regrettably the space wheel station, including all its staff and prisoner population, had suffered disaster and was lost.

Chapter 13 Extending the hand of friendship to the prison neighbors

As they stared at their "obituary" found via their fortuitous Asian internet connection, the implications slowly settling in, they realized that an effort to send messages that they were alive, would not be wise. Somebody big wanted the world to think they were gone, history. And permanently so. An effort to deny it would likely invite a missile coming up and silencing them, making it reality. As it was, at least they were alive. Wait and see, seemed the best mode right now.

They decided it best to make peace with their new neighbors, despite their initial rebuff from the prison guard staff, essentially telling them to stay out, stay away, don't come near us or we will shoot. How to connect with them? Probably they too had noticed that supply had ceased coming up, and presumably internet connection gone too. Were the staff members over there cognizant in advance re the abandonment, or were they just as surprised?

Catalie activated their one video link, put in when the first segment was made habitable by themselves. It had ended up being in a storage room, when the new wheel's arrangement was fleshed out by the new occupants, so it was pretty dull watching. Yet, it was the one link that still existed open between the two wheel space settlements. Eventually someone came into the storage area, and they recorded the activity, and examined it in detail afterwards. The person was in prison garb, so it looked like it was storage for prisoners use, not for the guards. Would the guards have the room bugged? Deciding to risk it, the next time a prisoner went in there, Improy used the voice link through the video monitor, to get the attention of the

prisoner and tell who he was. And advise of the new turn of events, and the need to communicate as soon as possible. Survival of all was at stake. The man in prison garb paused, listened, then continued on with digging through the boxes and left the room, not making a response. A few hours later, two of the prisoners showed up, one the same as before, who stayed to fiddle around by the doorway, while the new prisoner approached the video monitor. Improy again used the audio link and said hello, and repeated who he was and a brief description of the situation and need for cooperation. "Do you hear me?" was the response. Soon they were having a conversation, albeit awkwardly. The prisoners were used to video monitors, but the watchers normally were hostile, suspicious, and never talked to them; just responded with a sudden appearance of armed men if they got suspicious. So, this was a novel experience. The normal guards did not seem to have the imagination to concoct this as a new form of torture, so they chose to go along with Improy's information, see what would happen.

The prisoners advised that efforts to contact the prison staff would be much like interaction with Ownma Management, in that they were utterly steeped in dogma of their innate superiority, all others being little more than farm animals to be used for profit. "So what's new" Improy commented. A description of the internal arrangement of the prison wheel was gradually provided. The prison staff actually was quite small, and held one segment extending between two wheel spokes, and the hub. They had airlocks separating the staff area from the prisoner area, and had threatened the prisoners with having their air supply being vented to space if they ever tried to rebel. In fact, they had demonstrated it not long previous, by venting the prisoners' air into space until they were gasping for breath; then air was returned to them. It was a

convincing way to keep them in complete subservience, just as the guards intended. "Be careful of your contact with us; if the prison staff learned of it, they were likely to assault all concerned, perhaps even blow a hole into the original wheel to get rid of everyone there. Probably they would do that anyway, considering the new circumstance. Ownma Management had no toleration for any who opposed them, or even might oppose them in any way. The prisoners there knew of that too well. The "crime" most of them had been sent here for, was opposing Ownma just enough to try to get access to the means to survive the epidemic that was killing many of their loved ones. Going against the ultra-arrogant masters of intimate surveillance had always been very dangerous; but the lives of the employee's families had been at stake, and so were near lost anyway, so they tried. And failed; here they were.

A few weeks went by, and a good rapport was established between Number 283, as his uniform identified him, and Improy. The prisoner's affect visibly was cheering up, a bit of hope was enlivening him. His improved mood was having a beneficial effect on his fellow prisoners, too.

Unfortunately, the improved prisoner mood did not escape notice by the guard staff.

When the usual communication routine did not happen for two days in a row, Catalie got worried. "I feel something is wrong; we need to do something." Improy was a bit tense too, but said only that there was nothing they could do, except wait. They had to show good will to all concerned, especially to the prison staff.

One of the agricultural workers reported something strange out the sunward window, there appeared to be something moving rapidly out there,

and whizzed past every few minutes. A camera was set up and captured the event. Sent to the control room, the image was of a man in prison garb, out there with no spacesuit, tethered by a foot, the body rotating around so the number 283 was visible from the agricultural area of the prison wheel. It was also sometimes visible in the agricultural area of Improy and Catalie's wheel, too. It was a message from the prison guards, obviously.

Catalie blocked Improy's immediate move to head for the spacesuit area. "Hold off," she urged, "get rational about this. You can't save him, you know that; he is long past that possibility. That it was a result of your effort to connect with them over there, is not the same as you having done the wrong. Instead, let's re-weigh the nature of the beast we try to tame, based on this reality test." Improy simmered down enough to stop there; then he went to the gym to burn off the adrenaline before it went toxic in his bloodstream.

The next day, their video monitor of their internal hub area showed a group of armed prison guards headed toward them. The guards activated the airlock hatches, both left open, as all the hub was pressurized. Improy realized that their space worksuits were at risk, the armed guards headed toward the Embarcadero section. But instead of stopping to snatch the worksuits from their storage containers, they continued on to the Embarcadero's airlock, and activated the opening of both doors, as if the outer hatch had been sealed by an arriving space bus. But there was no space bus out there to seal the opening. Clearly their intent was to vent the air from the whole wheel. They hurried back toward their end of the hub as the doors began to swing open to the hard vacuum of space. But the hatches opened very fast. The rush of pressurized air from inside the station roared past the guards like a tornado.

And then the guards were nowhere in sight, blown out through the hatches, out into space.

Improy took the situation in, and activated the closure of the Embarcadero inner hatch from the control station. The rush of air was halted. Would another bunch of armed guards head out to finish the job? He closed the shaded end hub airlocks remotely, had Catalie stay there in case the guards re-appeared while Improy was out there. He hurried up the nearest spoke's ladder, up into the hub, and scrambled toward the now closed shaded side airlock. Reaching the power panel for the airlock, he popped open the circuit breaker, so the hatch could not open electrically. It could still be opened manually, however, from either side, including the attackers' side. Then he went into the Embarcadero, got their space worksuits, then returned to the wheel rim with them. From the control room, he activated the hatches sealing off all their spokes at the hub, then he re-opened the airlock hatch, venting the area to space. "That will keep them from getting into the hub to try that again, while we are sleeping" he coldly announced.

But the next morning, what he found was that the remaining hatch on the shaded end of the hub was open, manually unlatched from the other side. The whole hub was now open to space. "Now what are they up to?" he groused at Catalie. She replied that people who believed too much in their invincibility, would eventually learn of their real limits, or perish in their arrogance. Especially in areas where their surveillance did not give them secret info on where to easily hurt their baffled opponent.

The next evening they were surprised by a man in prisoner clothing coming back into the storeroom which had the video link. Not one they recognized,

however. Was it a guard being tricky? The man seemed to not know where the camera was, so he just talked into the air. "Are you there, somebody? What is happening?" The man looked scared. Catalie remarked that no arrogant guard would ever do that, even to be tricky. But this might just be a stakeout, a guard just out of sight. Improy risked talking with him. The prisoner said that most of the prisoners were not being let out anymore to go to the restroom or cafeteria; and that the group of prisoners, including himself, that had been out last, have been out for a whole day. They had been carrying food and water to the still locked up prisoners. But the guards were not activating food preparation anymore, and it was getting desperate over there. At least the guards had not vented their area into space again yet, thankfully. "Can you help us?"

"Do we want a companion wheel full of dead prisoners, while we struggle to survive with provision cutoff from the Earth?" Improy asked Catalie. Catalie pointed out that from what they had learned, that there were two agriculture and associated restaurant areas over there, just like in their wheel station. And if neither restaurants were operating, then the prison guard staff was not eating either. Perhaps Improy could go over and bargain with the guard staff, offering to get the restaurant equipment running again, in exchange for peace talks.

Improy had his space worksuit, but there was no way to re-pressurize the hub from their control room, as the power was off the interior hatch, so it could not be closed from here. So they both got into their worksuits, went to the rim airlock they had installed where the wayward bulkhead had long ago torn a hole, and they climbed down onto the "bicycle built for two" they had left there. Pedaling around to where the rope ladder led to the Embarcadero's hatch, they climbed up it, and

entered the airlock, both doors still open to space, and the Embarcadero in vacuum. Once inside, Improy proceeded down the hub, and closed the shaded side hub airlock hatches. Catalie closed the outer hatches and re-pressurized the Embarcadero. From the control station there, they looked in on the video link with the other wheel's storeroom, to find several prisoners in there now, who were greatly relieved to get a response from Improy. There had been no change in the situation over there, just getting worse, no food or water for anybody now.

Catalie said she was going with Improy; if it is a trap then she might as well end it then too. So the rest of the hub was re-pressurized, which took a huge amount of their air reserves to complete. "Why would that be?" Improy puzzled. "I hope we can negotiate for some of their air reserves, too." He lashed a small porthole-sized bulkhead to his left forearm, to fend off projectiles if necessary; then they proceeded into the prison half of the hub, finding the hatches open. They found a guard still with a deathgrip on the top of the spoke's ladder, clearly asphyxiated. Climbing down through the spoke, by the time they reached bottom, they knew what had happened. The guards had indeed attempted a sleep-cycle-nighttime repeat assault, but did not stop to check to see if the Embarcadero side was pressurized, when they opened the hatch into it. That would have unfortunately opened up the last barrier to space, and there were no airlocks between the hub, spokes and the wheel rim segment that the prison staff occupied. That they kept the airlocks sealed between their area and the prisoner's area, threatening to instantly vent the air from the prisoner's side, was what kept the prisoners from losing their air too; the airlocks work both ways. Examining the control panel down there, since everything was again pressurized, he soon had the airlock hatches in both directions open to

the prisoner's area. Then he sent the control signals to open all prisoner doors, and activate the restaurant facilities. Then they went back up the spoke, no telling how the prisoners would react at first.

Back in their own little condo area, home at last again, adventure too much today for either of them, Catalie did activate the link to the storeroom video link, for a last look in the area. What they saw there, was a sign scrawled with a big "THANK YOU" on it. It was time to get some sleep.

Chapter 14 Organizing after abandonment

Realizing that the 1,200 people living in the new wheel section had been living in the passive non-self-sufficient mode of prison cell inmates for a long time, and did not know any tasks for their own survival up there except tending the agricultural areas and associated restaurant areas, Catalie suggested that it was up to the people here in the original wheel to teach the former prisoners how to cope with life up there in the fullest terms. Eventually those 1,200 people could become helpful instead of a liability to them, she hoped.

All of them also needed to deal with their new status of being cut off from the Earth surface resources, even communication, except receive-only internet. While "playing dead" they also had to struggle mightily and creatively to live long term, if possible. From the former prisoners, they learned that after the epidemic subsided, only the mega-corporations including Ownma remained fully strong and functional, and corporate leadership power cravings had resulted in their now owning the governments of the world. Ownma had been getting money from the government to pay for the operation of prisons; but now that Ownma was government too, there was no profit to be gained by paying themselves to operate the prisons.

That was why they had been cut off from Earth, they were no longer a profitable enterprise for Ownma Corporation. For Ownma's ilk, it was mandatory to get rid of anything that was not maximally profitable. To them, declaring the wheel space station a loss was like taking a now useless domesticated animal out into the woods, leaving some food and water for it, and abandoning it there, forgotten thereafter. They really were on their own now.

Pep talks were in order. Improy set up a table over on the shady side wheel's rim near one of the cafeterias, with signs saying that their home here was now called "Leo Island", and to sign up at the table for duty, when they were ready. It was an instant success, everybody eventually filling out an electronic form at the table, providing name (without their previous prisoner number designation), their skill sets both basic and experiential, and a list of what they would like to usefully do at first.

Only a third of them were women, so except for the few couples among them, each of the women were randomly assigned multiple "husbands", and a beginning set of relationship rules were created for such marriages, including procedures for trading husbands, and for some husbands to be part-time husbands to more than one woman. And procedures for that group of people to change those rules by mutual agreements, based on how it worked out in reality. This way, no one would be left out completely, resulting in greater comfort and thus better productivity of everyone, and less strife potential, so long as all the members of a group relationship honored the needs of the other members.

Besides maintaining the agricultural, food preparation and housing functions, their abilities would need to become greatly diversified. Aiming at being able to establish a Leo Island capability to build and program computers to link everything in a coordinated way, each person was assigned time slots to use the computer terminal to input a description of how to do things that they already knew how to do, building a mutual knowledge base. The shady side wheel was re-arranged to nearly match that of the original wheel, establishing join-able living sections and setting up light industry sections. The industrial area was streamlined

to head quickly for a semiconductor processing capability in integrated circuit form. A basic research into hard vacuum environment materials processing facility was also established there, initially aiming for total extraction of purified elements from waste materials not directly recyclable in the existing operation of Leo Island. All material was precious, for it was all they could expect to have for a long time; they had to overall have a Pack Rat attitude. A 14-hour workday was established for the time being, partly to maximize accomplishments and partly because there was no recreation facility as yet, except for the gym. The work was set up to be easygoing, and have frequent breaktimes and changes in the kind of work done, throughout each workday. Each person's areas of activity were based as much as convenient upon the person's psyche, their individual Temperament.

Back in their own half of the dual space wheel settlement, Catalie and Improy's staff focused again on making usable space worksuits. Their one fabric and extrusion casting machine was pressed into service using discarded food containers into bolts of clothing fabric. Materials derived from cockroach exoskeletal material were used for the semi-rigid parts of a working spacesuit, although not of the augmented strength type, a function beyond their capability yet.

A couple dozen of the multiple-person family units were moved into their wheel, so as to make room for light industry sections in the shady side wheel, bringing the population of the shady side wheel down to 970 people, and bringing their own population up to 185. The two populations would even out more eventually, as arrangements best suited for optimum productivity and comfort of lifestyle were found. It would be a couple of decades before room would be needed for children reaching adulthood, needing their own

separate quarters. Lots of room for everybody at present, however.

Agriculture was the basic recycling system for nutritional hydrocarbon material, as in ancient times. But their species diversity was extremely limited. The agricultural species originally supplied to the prison wheel were different than those of the first wheel, so overall now included several new vegetables, peanuts, fruit-bearing bushes, turkeys and goats. An agricultural biology research station was created, first to document the knowledge they had amongst themselves to create a knowledge and skill base, then to fabricate microscopes and other tools for that area, headed toward a DNA analysis and synthesis capability as soon as possible.

The original prison staff area had been supplied with a telescope, for unknown reasons, probably related to their psychological makeup that hungered to monitor everything going on; even in space around them beyond the space station, apparently. Mounted on the sidewall of the wheel station, it had a nice de-spin mechanism and vibration de-coupling mount, and sent its pictures in digitally. Several people volunteered to take charge of it, make it useful besides peering at what people were doing on the ground.

One of the early concerns was to compare their trajectory with the position of the anchored tether space elevator that Improy and Catalie had helped create several years before. They had known that the path would not cause collision with the tether for several years, back at the start; and it had been originally intended to occasionally use reaction motors to shift orbit slightly so as to pass by even if originally headed toward collision. All that had been lost now, however, and needed re-discovery. What to do with the

information, however, was yet to be determined. They had no fuel for reaction motor driven position shifting anymore.

They chose to define their location as being in line with some place on the planet, as if a line between the wheel station and the center of the Earth, and where it intersected the planetary surface, was its location. They created a map, showing where they were, that way; and compared it with the known location of the old space elevator, which was anchored to a floating island on the Equator in the Pacific Ocean. To define where they were at any time, they centered the image of the planet, and that was where they were above then, what appeared center of the planet’s disk image. The couple who had chosen to volunteer for the astronomy task plotted this position as a function of time, using the time together in the observatory as a chance to get away from the teeming busy wheel station in general. Volunteer tasks were set up to provide a few little benefits like that to those who did the volunteering.

Most of the former prisoners eagerly chose volunteer tasks to do. It was a relief from the caged boredom of before; gave them a sense of doing something worthwhile and thus improved their self esteem; and the tasks often had a special little benefit to those who did them. At this point, everything that got done was by volunteers. No formal employment status system had been created yet. That was partly because they had to first establish a monetary system.

Catalie started the subject with Improy one morning during breakfast. "Ought we pay the cockroaches for their contribution to the protein balance of our breakfast?" she began. Improy was silent while he munched more of his breakfast, at first trying to

make some sense of the question that had come out of the blue from his beloved mate; then exploring the implications of the question. It took several more spoons full of breakfast cereal, and a couple sips of tea, buying time to make some rational reply. "They certainly made a beneficial contribution to breakfast nutrition, yes." he began, not sure where this was going. "What kind of currency would cockroaches be paid in?"

"Consider money as the ability to do work." she replied. "After all, money pays salaries to have people do some activity; and buying some product pays for the work in making it, including the work of obtaining its materials." She paused thoughtfully a moment, then "in Physics, energy is also defined as the ability to do work. So maybe the cockroaches could be paid in killowatt-hours, to be spent in making their environment more suitable for them and to provide better food." His reply was "Yet we get kilowatt-hours of energy from the Sun as converted by our solar panels outside, into electrical energy that runs our machines. How does this figure in?"

"All energy comes from solar sources. The fossil fuels that powered civilizations' rise to a technological system, derived their energy from solar energy received by vegetation hundreds of millions of years ago. And nuclear energy comes from energy forged in solar furnaces, fission from such furnaces very long ago. So energy is a flow. Just how much one's sails get a push from that flow is determined by how much energy is intercepted. That "intercepted energy flow" is the amount of work that has been utilized to modify your environment, whether it is to make the air warmer or to make a product for sale to someone else," she continued.

He began to feel that he was losing his grasp on this conversation. "Does this boil down to the situation that if the cockroaches are no longer are used to improve our food and to make spacesuit and shoe raw materials, they get the boot into space?" he replied, "Like we were given the boot by Ownma Corp., when we no longer were profitable to them?"

"When one stretches out in the sunshine, the Sun gives them warmth, energy for making vitamin D and to tan the skin," no charge." she replied after a moment. "The source of all energy does not give anyone the boot." He responded "Yeah, but when one's paycheck gets terminated, so does the ability to buy groceries and pay rent, essentially getting the boot. So where does all this get us?"

"Why do we have a monetary system?" she asked. "If it is used to establish the value of something, what is the meaning of that term 'value'? Maybe that is what we ought to base the monetary system on, is 'value', not the ability to do work."

"Value is set by a bidding system, a bargaining thing. A game function. Do we want a monetary system based on such a capricious thing? A drink of cool clear water to a man dying of thirst in the desert has far more value than the same amount of water in a lake."

"What is the amount of work that has to be done to provide that drink of cool, clear water, to the person in the desert at that critical time, as compared to providing the same drink of cool, clear water at the lake source itself?" she pointed out." True, the provider of the water may hold out for huge sums of money before giving the desperately needed water. So it is not just the work done to get the water to the one in need of it, but also the desperation of need for it, and the intent of

the provider to extract as much value away from the person in need as possible, regardless of the amount of investment in the work of bringing it to the desperate person."

"And perhaps there is a risk factor involved. For example, if two people do the work of bringing the drink of water to the point of need, but only one glass of water is needed; one provider gets paid, while the other provider has lost all reward for the effort done, it is wasted effort.'

"If reward is based on the amount of time someone has spent doing something, there is no equality between someone who lazily does a little bit of work during the same time another person does their work in a frenzy, doing many times as much product in that same time."

"At one time, the concept of 'Value Added' was thought to be a fair measure of increase in price. But in that concept, the buying up of all of a limited commodity, then forcing the normal users to pay more for it even though it was no more useful to them than before, would have added no value to it other than through artificially created scarcity, holding the material hostage, in a sense. No utilitarian value was added, but the cost went up anyway; someone made profit but did not increase the usefulness of the product handled."

"Well, how about making the unit of money to be equal to a certain fraction of the total worth of the system in which one lives? Then it ought to be possible somehow to derive a percentage value for any particular thing. Although actually I can't think of how, right now." So they finished their breakfast philosophizing with volunteering still as the basis for getting anything done, at this point.

Chapter 15 A Corporation of employees

Most everybody was very glad to have the help of the others up here, improving the chances of making life work in this strange inhospitable place all have found themselves in now. Volunteering duty accomplishment was adequate thanks for tasks each person did, at least for now. At least they did not have to have money to pay rent or for groceries, at this point; instead, they had to pitch in to make food grow and the place stay livable. So for now the question of how to create a monetary system was put off, there were too many other things that had to be done each moment, just to survive.

The couple who had taken on the task of getting the telescope working to locate their position relative to the space elevator tether location, had been plotting their position over a map of the globe, not unlike the appearance of the old photos of Houston Mission control showing path of the Space Shuttle, many decades ago, overlaying the Earth's globe of land and sea with sinuous curves iterated across the map, orbit after orbit. They did not know exactly where on the Equatorial Pacific Ocean the tether was, unfortunately. They had made some wide angle telescopic images of possible places it could be, that is, of the former floating oil rigs which were the artificial island the tether was anchored to. They showed Catalie one such photo of an object in the ocean. "Yes, that's it!" she exclaimed, a bit too excitedly, no doubt bringing back memories of adventures there a few years before. So the next time around that area, they got a close-up image of the object, along with data relative to their orbit. Catalie pointed out that it looked abandoned, just the three floating oil rigs lashed together, and no boats docked, no people on the rigs. Had the tether fallen already?

The couple had also done calculations that showed that if the tether were exactly above that spot, that it would be in the path of their space station wheel during an orbit happening only 4 months from now.

"That eventuality could have been why they abandoned the space elevator project, even though it was looking so promising" Improy mused, upon hearing that news. In a survival contest for rights of occupancy of a specific piece of space, the enormous tensile strength of the carbon nanotube composite fiber tether, already stretched to limits of its working stress, would be no match for the impact of this mammoth mile-diameter wheel of a space station traveling at some 17,000 mph relative velocity when they met, hundreds of kilometers above the blue Pacific. "Let it go," Catalie urged, "we probably won't even know the contact happened." But Improy continued to ponder on and off during the following weeks, how to possibly save some of the space elevator structure, of which he had given so much of his life efforts to make into reality. Nevermind that Ownma Corporation had obviously expected the project to fail during construction, and Improy with it; and so surely had never expected it to be successfully built, let alone now survive impact from objects orbiting below GEO. The Space Elevator was just an abandoned, forgotten White Elephant to Ownma Corporation at this point.

The original pep talk given by Improy, set a model for what became a routine focusing on their mutual goals, once a week. Catalie usually came up with a theme for each meeting, but this next one had yet to have the light of inspiration happen for its theme. Improy showed up as usual, in front of the gathered staff, still without knowing what to say, so he improvised on his own, on the spot. "This difficult situation we are in" he began, "is a result of the ultra-corrupt thing that

Ownma Corporation has become. It did not escape the old adage that absolute power corrupts absolutely. Yet, our efforts here are being done quite differently than work done under the slave masters of Ownma Corporation; we are making it work. Yet, could such scattered efforts have ever created such a thing as this pair of space station wheels? A Corporation ought to be a form of government that is focused on getting products to be created and put in the hands of those who need the products. And that is the kind of thing we need to do right here and now, to have our efforts not just survive for the moment, but also to go for an even better situation for all of us. Could we create a Corporation .... no, not like the Ownma Corporation ... a corporation that is product oriented instead of profit oriented?"

He looked out on the faces, hoped he saw some of them shifting from angry memories of the bullying tragedies heaped upon them by the Ownma Corporation's elitist monkeybusiness, shifting to a more thoughtful look. "How would each of you design a corporation that got us to work more effectively together toward all our goals, and yet had safeguards built into the corporate structure so that it could not decay into the mess of Ownma? How would you do it? An Employee-owned and operated corporation, let's call it "Emplos Corporation" as it helps for something to have a name to become more concrete." So, that was the weekly meeting's assignment, to write how they would design such a corporation, in each person's individual words, whatever came up for them on the subject during the following week. It provided something to think about, besides how to do their still awkward tasks in such a strange machine world, so far from a home, and that home no longer had a welcome place for any of them. At least here they had food, shelter, companionship; and for now, had a tomorrow to look

forward to. A tomorrow that perhaps they could influence its ways, too. Could it be?

Chapter 16 Cockroach spacesuits

Emplos Corporation, comprising all the people on board the dual space wheel, had their first vote, even though all 1,345 of them had only the one computer terminal to vote on. They supported Improy's goal of creating workable space worksuits made from their own resources. And supported Catalie's goal of creating a capability of building and programming computers from their own resources. A third goal was added by the other crew members, that of examining the one sample re-usable cargo vehicle that was winged for a return that had not happened yet, see if it could be made into something that could return people safely to the Earth's surface, and if so, see if they could make more of them from the huge collection of spent one-way cargo and bus modules that were lashed to the hub.

To create return vehicles, it would be very helpful to have more space suited workers, and computers to assist their activities. It would also be helpful to have more than the two docking airlocks. In the small world they inhabited, it was fairly easy to see that everything was affecting everything else, every goal was affected by the progress of the other goals. There was so much to be done, that in the next week's voting they chose to continue the 14-hour, 7 day a week workschedule, with the easygoing work style which included frequent breaktimes and frequent complete changes in the kind of tasks each person did during the day.

The computer and electronics technology development and the spacesuit technology activities were focused on first. Semiconductor materials processing facilities were created to utilize the endless hard vacuum outside, the intense energy influx in the

direction of the Sun, and the deep cold sink when aimed at the space between the stars. They pulled the teleoperation electronics and mechanisms out of some of the habitat modules in which they lived; that equipment had been essentially forgotten following successful docking of each module, so they had many hundreds of them, sources of radio parts and computer chips, even as sources of raw material when not adaptable directly. From these modules, they first built short range transceivers so necessary for communication when in spacesuits.

The first prototype spacesuits were nicknamed "Cockroaches" for the use of cockroach exoskeleton material for making the more rigid sections of the suit. For the first ones they used fabric processed already from discarded plastic food containers, but soon they would have to also make fabrics out of other components of the chemical marvel that was the little cockroach, which busily consumed agricultural wastes to make more of itself, quite a materials processor in its own right. The first prototypes were tested by putting them into an airlock, pumping it down, and observing what happened to the sealed suit. From that experimental data, some areas of the components were strengthened for the next prototypes. Eventually, Improy assembled one of the "cockroach" spacesuits around himself, tested its radio link, went into the airlock, and had Catalie pump it down while chatting with him over the radio link. When it appeared that the suit was holding up with a motionless person in it, he then experimented moving some joints. That was where it showed problems next, as an elbow joint was stiff at first, then cracked, air escaping through the crack, and Catalie quickly re-pressurized the airlock; back to the drawing board they went, having more data to guide them. And soon they had a basic space worksuit created out of their own resources, even

though these ones they made themselves did not have the servomechanisms and super strength rigid materials needed to amplify their motions while working in space. At least now, they could start doing work outside to make the new multiple airlock hard vacuum materials processing module, needed to start work on the potential return vehicle design.

As improved designs were created for the Cockroach spacesuit, the prototypes got tested more severely in the airlock, Improy's frolics sometimes creatively comical. He even added some style features, such as the two little tails the male cockroach has and a rooster's crest on the helmet. They were going to have a little fun while doing their project. The suits that had failed in test were easily recycled, just given back to the little cockroaches who promptly considered them food. This also meant that the suits would need to be kept away from stray critters, during normal usage, too.

When they had three of the working spacesuits, three volunteers went outside in them with Improy, Catalie staying inside the Embarcadero, monitoring progress. They did this every other day until the volunteers had learned the safety rules out there and their reflexes had learned to deal with free-fall inside the suit, what made it all work fairly smoothly. Only then did Improy introduce his new crew to the one sample of a vehicle designed for use as a return cargo vehicle, a one of a kind since apparently Ownma lost the means to build them when the epidemic struck.

It looked like it might get hot inside on the return, based on the small airfoil surface, as compared to that of the earlier Space Shuttle Orbiter re-entry vehicle. The thermal insulating tiles looked difficult to make in all those special shapes, and tracking of manufacture looked difficult for their meager computer resources. Of

course there were no facilities for people inside, all of which would need to be added. The discarded one-way space busses that had brought all the people here, had such seating and air supply systems; perhaps a good start on the envisioned vehicle. So the making of insulating re-entry insulation needed to be somehow created. Perhaps they could do zero-g casting of foamed materials, the lack of gravity enabling bubbles to cool hard before they burst.

Their design activity produced essentially an add-on component to the space bus: a large swept back winged structure cast of foam into shape, complete with cradle for the space bus, and the foamed structure covering the nose and underside of the passenger compartment. As the foamed part would be made from the material of the fuel tank area of the original one-way space buss, it would take little from the wheel station's resources to build. The large winged area would, they hoped, enable the vehicle to have little heat to endure while it bounces on and off the upper atmosphere, going all the way around the planet several times to lose velocity, until the vehicle could make an easygoing lazy glide down through the dense lower atmosphere to a slow, but skidding, landing, since they had no landing gear.

Providing reaction engines and fuel for the de-orbit and semi-powered trip to the ground, was the next challenge they needed to solve creatively.

The original sample return vehicle was the only thing that had any fuel for de-orbiting, and probably only enough for its empty mass. The slowing needed to be enough to drop not just to a lower orbit, but one that got them into the atmosphere for slowing down for the landing. The most efficient way was to build a launcher along the outer shell of the hub, as long as possible,

and use stored solar energy to shove the vehicle backwards to slow it, while also moving the space wheel into a higher orbit at the same time, a double win. But that would not in itself be enough delta-vee to drop to the upper atmosphere. And there had to be maneuvering reaction engine power to guide the process back home. They needed to be able to get in the right attitude when reaching the atmosphere to enable them to pancake along, bouncing and maneuvering so as to be headed the right way when coming down again each skip and bounce on the upper atmosphere while they gently used up kinetic energy. The only reaction mass they could tolerate expending was ground up fuel tank material, so they had to come up with an efficient mass launcher of fine powder derived from more of the fuel tank material. Modification of the docking thrusters and their fuel tankage would be nice recycle if it could be made to work.

So it was agreed to proceed with making a casting with the hollowed shape of the wings and cradling thermal shield and nose cone, which would be clamped together and have solar-melted air-bubbled material from fuel tank casing injected into it, in a vacuum; then it would be cooled by radiating into deep space until hard, then the mold would be opened to remove the foamed shaped return vehicle structure into which a passenger section of a former one-way space bus would be secured. The controls for the rudder and ailerons needed to be routed to a pilot's position, vision via one of the thousands of security cameras that had been in the former prison facilities, A simulator would need to be built to train to fly the thing, as none of them were pilots.

It would take a lot of time to do all this; but they had a lot of time, and needed a vision of survival.

They also continued to make the space dual wheel able to have long term survival, increasingly refining the balancing of the homeostasis of the huge complex of living systems and machine systems. Some people might elect to live out their lives there, even raise families to continue on.

But their resources were meager as compared to that of the 10,000-person Stanford Torus design for which this project was originally conceived to prepare for. There was just not enough diversity of knowledge, of people skills, of agricultural species. They were determined to do the best they could with what they had.

Meanwhile, the encounter with the space elevator tether grew closer. Improy was determined to make an effort to salvage something of it. Refinements of the telescope's observations had been able to determine that they were going to hit the tether dual ribbon almost flat-on, so they rigged up one of the space bus cylinders to spin easily on its central axis, and placed it so it would do the initial impact with the carbon nanotube tether. This blunt edge that could spinup to roll along the tether, assuming the impact would jerk the anchor end up out of the floating island's guideway, greatly exceeding its range of accommodation. It the tether ribbons did not break, and they began to roll along the improvised pulley they had rigged for the collision, if things worked out, the drag on the tether would keep it from immediately losing in the GEO station from heading out and instead start to be dragged along with the wheel station, whose angular velocity was far greater that that of earth. So they would have to reel in the tether and everything that was in GEO now and the counterweight beyond GEO. If anything snapped, they hoped to have captured a big chunk of the super-strength tether, anyway.

Then the moment of impact came. Improy had worked until the last hour to orient the huge pulley along their orbital path, rigged to their hub's orientation calculated existing at the moment of impact. Then everybody was ordered inside, to watch through the telescope's signal sent to the station's viewscreens. The telescope could barely see the black line of the tether, which rapidly grew more visible, then there was a tiny shudder of the whole station. Impact, the pulley was spinning increasingly fast, so the tether had been uprooted and had not broken so far. Their luck held, and they began to reel in their big fish. But the tether pair snapped, up high, where the tensile loads were already approaching working stress limits; and the sudden overload from down below pushed the tether beyond its limits, and broke. Unbalanced, the GEO station unfortunately would get pulled up and away by the counterweight above it, lost. But Improy was able to reel in hundreds of kilometers of tether ribbon from above and below them, a fine resource for future projects. So something was saved from it all.

Chapter 17 A piece of tether can be useful

Improy was quick to get outside to inspect his catch, having saved a bit of the unfortunate Space Elevator, as soon as the telescope observations confirmed that the tether ends were not flailing around dangerously anymore, having used the initial differential velocity between it and the space station to wrap around the "pulley" like a tetherball wraps around its maypole. Measuring the overall thickness and estimating its packing density on the 10 meter diameter pulley-spool, that they had saved about 1,500 kilometers of the ribbon. "Just what do you plan to do with the stuff, now that you have got it?" Catalie asked him. He answered that he had hoped for retrieving some of the station, but would take what he got. "I have not figured out exactly what to do with it, but material resources up here are hard to acquire." He went on, "One thing I have thought of, is to use it to lower one of our manned return vehicles down to about graze the upper atmosphere a small but noticeable amount. At that position, our overall angular velocity around the planet ought to be same as it is now, but the station here will be slightly higher. The tethered vehicle will have significant "weight" felt in it since they would be going far slower than orbital velocity at that altitude, constrained to our angular velocity. Then they disconnect from the tether, drop into the atmosphere, and begin their skip around the planet awhile, until their velocity has slowed enough for a safe decent through the lower atmosphere. If they are willing to have an entirely unpowered glide return, flown only by their airfoil control surfaces by the pilot, the whole thing could be done without any expenditure of propellant for de-orbit. And the station here will be simultaneously boosted to a slightly higher energy orbit, same energy

as if we had launched the return vehicle backward along our orbital path the amount to de-orbit, and the reaction shoving the station forward a bit into a higher orbit in the process." Catalie reflected that it would then solve the problem of lack of propellant for de-orbiting the returning vehicles. "Neat." she responded.

Minor re-design of the first several return vehicles was made to utilize this technique for de-orbiting. A nose clamp was installed that was releasable by either the pilot or the orbiting station control center by radio link. Hoping to avoid the need to build gyros for changing the vehicle's attitude in space, they prepared an empty area where a crewperson could deliberately spin around a certain number of times, then stop. While he was spinning himself, having pushed away from the structure of the vehicle, the vehicle would rotate in the opposite direction until he stopped spinning. Each change in the design prototype, they would go verify that it would work, but safely up here. And they tested out the idea of a person doing spins instead of using a gyro, which required both physical agility, endurance, and body mass.

It became a bit of a combination of testing, physical exercise, and a bit of adventurousness each time a volunteer would go practice the spacecraft attitude control that way. The effect was small, as the spacecraft mass was far greater than the person; but it did have an effect. Tubby people definitely had the advantage in that freefall environment sport.

Little by little during each test they lowered the tethered spacecraft further, practiced unlatching the tether while being secured by a safety line. Further down, they added testing to determine the minimum RF power needed for a directional antenna link, not wanting to have their signals picked up by Ownma staff

on the ground. Finally they did a full length lowering test, so as to test how well the craft oriented in the upper reaches of the atmosphere. Due to the slow solar-powered winch lift backup to the station, it took a whole week to do; and so air, food and water could support only a few people for the round trip. All of them volunteered for the test, and some hoped to be on the first real decent test to the ground later. Each of them had trained to be both pilot and gyro.

Exactly how far the distance would be to the effective beginnings of the atmosphere from where they were, was unknown; nor could they accurately measure the length of tether payed out. So the first data produced by the test was that they needed a way to tell if they had arrived or not. They did reach a distance down that their spacecraft seemed to be getting well oriented nose toward the path they were taking over the planet. Enough for one day, pull us up, they asked. The tether spool was marked so at least they could later repeat that distance, and they reversed the winch direction, and the return trip up was on its way.

A test data evaluation meeting with the returned adventurers produced some interesting suggestions. A drogue vehicle would help determine atmospheric density, say with a wind driven propellor rotation rate providing the data. That was expanded to become a propellor driven air compressor, storing air in a tank that would then get pulled up after the deployment of the return vehicle, and that way they could do some replenishment of their air supply. The release of the lowered vehicle would give energy to the station anyway, so some of that added energy could be used to scoop up some air.

So they got diverted to the task of building this scoop drogue, and testing it out by itself. Its tank would

be significant mass and would have to be hauled up along with test airframe vehicles, slowing the winch up process, already days long.

Actually starting to believe that they might be able to return to the Earth's surface, planning as to where to go became an issue. Their monitoring of their receive-only internet link told of an increasingly powerful worldwide corporate takeover of most nations, in their various economies disrupted by the terrible epidemic. Ownma Corporation was foremost in this takeover, and appeared just as ruthless and arrogant as ever, as if they had won the world in a poker game and were raking in the chips. No compassion for the "chips" whatsoever.

The need for survival of the masses was all that sustained the system, and the big corporations just sapped that life energy from the masses, easy. So where could they land? The physical requirements were one factor; the situation they would find there was another. Landing where Ownma found them, would just land them in some prison down there again; and if the returning vehicle were found, they would realize what was happening and likely send up a rocket with a warhead to end the space station for sure. And the space wheel station had no way to duck.

Another issue they found was the determination of who to go first, and who second, and so forth. What they found was that there were plenty of brave volunteers, but none who actually wanted to go. As tough as life was up here, it was a far better life than any of them had experienced ever, and their self-determination form of corporation, their Emplos Corporation, was working for them, and nothing like it existed down there. So what happened was that there were endless design reviews, tweaking of the design,

modifications to the return vehicles, ever making it more likely to succeed; but more importantly it was buying them all time to be together.

Occasionally they would send down the air scoopship drogue vehicle, gathering up air for the station, while conducting various tests of the tether system. They polished up the return vehicles, building more of them than very wise for an incompletely tested design, but they considered that once they starting leaving that maybe a lot of them would have to leave in a short time for some reason. They used the telescope to inspect potential landing areas, on and on.

They were also making a lot of progress on making the dual space wheel a long term livable place. The turkeys and goats were providing meat in larger quantities than the original quail and their tiny eggs; cockroach protein was still a staple addition to breakfast cereal; the goats also were starting to provide goat milk and goat cheese. The endless abundant sunlight provided luxurious grains and vegetables. Some otherwise decorative plants provided cleanup of the airborne toxins.

Solar power was their only energy source, but it was widely diverse in its ways of usage. It powered the growth of the plants, of course. It provided final distillation of their drinking water. Through solar panels it provided electrical energy. In many industrial processes, its heat input provided processing temperatures of whatever was desired. It provided excitation for some industrial laser applications.

Yet another workhorse application of solar energy was in its developmental stage, that which promised total recycling of any material, which would be extremely useful in their tiny closed ecosystem. It

started with intense focus of solar energy onto the input waste material, several stages of heating resulted in the material in a plasma form. Gating constant pressure plasma into puffs into the hard vacuum produced a fairly consistent velocity of the material as it shot through a strong magnetic field, bending the trajectory of each particle according to its mass/charge ratio. Containers put at the location of each mass/charge ratio intersection with a perimeter, gathered just the material that had a specific mass for its charge. Too hot to be chemically combined with each other, the various elements bent around to head into their respective catchers. When a catcher would become full, it would be harvested and a fresh empty one put in its place. The harvested materials were pure elements, ready for direct materials processing.

From such resources as these, a semiconductor facility was supplied, and gradually began to produce ever more complex integrated circuits, at first for sensors, then communications equipment, then computers finally getting built. This had been one of their milestone goals, which enabled the next goals.

One of these was an education system distributed to everyone, wherever they were at at any time, per their desire. At their workstation, it provided data links recording their progress on each task they did during their workday; and in between when it was doing that, it provided simulation so as to teach the person new skills. Education was oriented to doing specific tasks which needed to be done; the rapid shift of kind of simulation enabled education on a huge variety of skills, often including "pure" science that was plug-able into many kinds of uses when combined with specifics of some ongoing task. The original input of each person's knowledge and skill base was thus sharable to all who needed it to perform some task right

before them at the moment. This original knowledge base was then incremented by the accumulating results of each person at their workstations.

Chapter 18 Exodus contingency planning

The application of education being intimately applied to application on the spot each moment of the work task, was easily expanded to include other tasks too. Sports being learned, such as the "I'm a gyroscope" activity, for example. Rapid creation and inclusion of terminology to fit the education need was a key part of its success, for example, the terminology communicating the complex neuromuscular sequence patterns involved in "being a gyroscope," and had its variations among the range of free-fall to artificial 1-g at the wheel's rim, coriolis included. It also enabled rapid response to medical emergency, the education going right to the people on the spot, and later joined by what expert people were among them, if any. So the computer network was becoming a benign coordinator, by offering the accumulated knowledge in its database to every person at every instant. The rate of assimilation of that education on the spot, even in crisis mode, provided the limits of its effectiveness.

Sometimes that meant un-learning some part of what one already knew. For example, the computer input keyboard key designations used was inspired by the the Dvorak layout, so the people who had learned the qwerty form of layout needed to unlearn their earlier reflexive typing mode while adopting the more efficient movement typing mode. The increasingly complex and rapid real-time inputs and outputs required while performing a wide variety of kinds of tasks was rapidly indicating that the typing keyboard was not the optimum input device.

The best part of it all was that they were developing a working system that made up quite a bit for their limited number of personnel on the station, as

compared to the wide diversity of skills, talents, and sheer numbers of workstations needed to operate a self contained world.

And it also became apparent that everyone was needed to make the space wheel go around without tripping over itself constantly. So if any of them took the return vehicles back to the Earth's surface, it would make it more difficult for the remainder to keep the whole system working best possible.

They came to the conclusion, during one of their weekly meetings and vote sessions, that they needed to gradually build an exodus fleet of vehicles, all leave for Earth at the same time. Agreed on this, they then were confronted by that standard exodus vehicle being an untested design. There were a lot of factors that would play out in the return trip, and how they would interact was not fully guess-able from what they now knew. And no doubt each flight would encounter somewhat different situations from the others, even if only the effect of precedence. The passage of a vehicle would change the characteristics of the path to some extent, for example. If a hostile entity spotted some of the re-entry vehicles, their attempts at assault would bring in even more kinds of factors, like, how to dodge rocket-borne warheads while also not leading the aggressor to one's new intended home.

Since they had plenty of tether belt material, they chose to have a primary decent tether that was a closed loop, and a secondary tether that was of the type they had already tested, but would take a cycle time of abut two days per vehicle. They had plenty of collected one-way space busses lashed to the hub, so they chose a comfortable design of only five people for each vehicle, with the idea that there might be an option to live in the landed vehicles for an extended

time, that is, as homes from which to go to and from, while they built up a new city somewhere on the surface. So that meant building 30 vehicles, having one to spare. Fewer people per vehicle meant they could build sleeping accommodations and computerized education living systems into each vehicle, so they would be able to utilize their newly developed education system of linkage to real time activities. No doubt they would face severe adversities down there, and they needed all the advantage they could create beforehand.

They would also distribute their livestock and samples of their feed and seed stock among the various return vehicles. Getting this all planned and ready, bit by bit, without a scheduled exodus date, was the mode of living for a long time, as they psychologically accommodated to either staying up where they were, or leaving for the ground.

Chapter 19 Lurking bully in their midst

Their use of their mini-internet computer system to provide "instant education at the point of need" made up for their lack of facilities for higher education and years for everybody to devote exclusively to that schooling, than for them to try to remember what they had learned when they needed to do something new on the job. More than that, their computer network provided linking necessary for community to operate. The shared vision which provided their bonding of community. Yet there were many sub-visions, shared by some but not others. The computers helped identify where those sub-visions required the same resources exclusive use, too, and offered ranges of alternative resources to examine.

The vast majority of the original prison population, sent there as a life sentence without possibility of parole, were politico-corporate prisoners, people who had opposed the corporate agenda that was causing harm to the masses of employees and consumers. These adapted seamlessly into the community vision sharing via the computer network.

But among the prisoners were a few who really were more ego-driven, whose visions were more of the type motivated by urge to gain by interfering with those who they perceived as rivals among the space station wheel people, seeing others' loss as their gain, and craving to show the girls who was the better man by being able to cause harm to the "rival." Although most of the time they found that their needs were fulfilled by going along with the group's shared goodies, and doing some tasks that supported what needed to be done for all their survival, sometimes their old conditioning kicked in and their egomania took over. The computer

network struggled to cope with those erroneous inputs, as did the whole space station population, when that monkeybusiness was expressing somewhere.

Catalie was chatting with Improy during breakfast, pointing at the computer screen. "I have been testing out some pattern filling-in mode software for the computer network, that test for congruency." she began. "It has a hierarchy of shared visions as contributed by each person up here. Yours and mine are in there for all to see, as are each other person's visions. As a check I find that the computer indeed discovers the unanimous visions among us. It has also identified the parallel but inconsistent overall patterns, such as of making life up here very long term, vs exodus back to the ground. And it identifies quite a few sub-visions that disharmoniously overlap in places, such as agriculture's usage of water resources vs industrial's uses of the water. Yet, curiously it has found another pattern, which seems to be that of 'whatever Improy decides, I oppose.' It does not seem to care if it is inconsistent within itself, either. So it looks to me like it is a case of the old egobrain in someone here, attempting to depose the king, in its perception, no doubt per that pattern, to take over the kingship himself." Improy looked thoughtful for a moment, then asked if the computer pattern-filling provided pointers toward probable areas of damage the "rival" might strive to do. Having unnecessary struggles to cope with was not a pleasant prospect for Improy; battle for dominion was just a huge waste of precious resources, in his opinion, and best left to the lower animals to entertain themselves with, and was not fitting for humans to do anymore. Especially up here!

And the thought of someone considering Improy as a "king" was amusing to both of them. They considered themselves simply parts of the great combo

of living systems and machine systems that was the space dual-wheel station.

Over in the shaded side wheel of the space station, Stable was thinking over his situation up here. His job was as the long term informer for the prison guards; but when they had all blown themselves out of the picture, he was suddenly all alone. Very sociable and talkative, he fit in fine with any group. Yet he knew of his situation, and the increasing spread of knowledge around up here was risking revealing his background. He had been born into Ownma Management, not of the Employees. But by the time he reached the age of the Testing, it was obvious that he would not pass. At the age of 14, all progeny born of the Ownma Corporation people, were put through the Testing. For one thing, he was short, only 6 foot 5" tall, and the passage minimum height was 6 feet 6" tall. He was adequately psychic, so he could pick up on test answers in school easy enough from classmates, and guess their intentions before they knew themselves, so that part he passed. But he was only 230 pounds, and just could not get to the minimum weight for passage of 245 pounds of lean muscle and bone. He was from the most influential of Ownma men, however, so when it was time to put down all those who had not passed the test, Stable's parents saved his life by having him put in the position of lifelong informant in the prison system. He was disowned, of course, and all of his classmates who had not passed the Testing had been euthanized, for their genes could not be allowed to contaminate the super race that was Corporate Management, whose impressiveness was enforced by their eugenics program. He had nowhere he could go from there, he was dead as far as Ownma knew. Among the Employees, he was far the most powerful and cunning, aware of the activities and to some extent even the thoughts of those around him, a powerful person

indeed, among these inferior species, the Employees. But that computer data gathering system, he feared, was too smart and would figure him out, and then these people would tear him apart in fury, surely. And, despite his superior strength, there were too many of them. Besides, he needed them to provide what he needed. Were they not rightfully his employees now, he the only Ownma Management here? The problem was, that there was no management here, for him to assault and take over their position. It was the computer network, and the leadership of Improy and his mate. He was bred to see his reality in terms of who was hierarchically above and below him, and to ever kick down those under him while striving to take over the position of the one above him, it had ever been that way, in the intensely person oriented world he perceived. "Things" like computers were almost non-existent to his awareness; it was only people that existed, in his kind of mind. So, Improy was his target to prove superiority by vanquishing. Possession of "things" came along with position in the hierarchy. So he set out to dispose of Improy in a way that showed the superiority of Stable. For now, he just observed everything that Improy suggested on the computer network, then Stable just said the opposite. That way he could look like he knew as much as Improy. Eventually he had to "get into" Improy's mind, to cause Improy to have an inner saboteur, weakening him, and knowing what Improy's next moves would be, so Stable could get there ahead of him. This kind of stalking and assault was bred into Stable's genes, that part passed the Testing. It was just that he was not quite big enough to have lived past the Testing. Of course, none of the men here would have passed the Testing; in fact, he sneered, none of them would have even passed the birth measurement criteria, to live another day.

Catalie set the computer network to have a threshold of tolerance for disruptive activity, and to signal her when something went past the quite wide threshold. Immediately upon setting this up, its first evaluation signaled an over-threshold event. Did she set the tolerance too low? she thought as she accessed the tagged event. Oh, she realized, it was just the oddity of some frequent differences of opinion with Improy's comments and suggestions. Looking closer, she was surprised that it was a 100% correlation; regardless of Improy's position on a subject, this same person was on the opposite side of the issue, even when Improy had changed his viewpoint then so did this individual change to support Improy's prior position. It made no sense. Was someone just being contrary, argumentative? If so, why?

She decided to do an experiment: she asked Improy to put a viewpoint on the network, that was a test case. Improy then put up an opinion that the shaded wheel should not be vented to space to get rid of any cockroaches that might have gotten over there, even though none had been seen there yet. Bingo, within minutes there was an opinion put on the network that the shaded side wheel should be vented to space to get rid of any cockroaches that might be hiding somewhere there, and to do it immediately, before anything else was done. The source was a man who was even in the shaded side wheel. So, it was someone just being contrary, argumentative. It was one of the former prisoners, although he had not yet been very helpful in volunteering at doing any of the tasks available. The profile on him said his name was Stable and that he was a very popular man in the area, a real people-person. So, why would he be doing the strange opinion activity? He had not shown any prior interest in any activity except being a buddy to everybody he could get near. That was an important function, she and

Improy believed, uniting the space station personnel's efforts while enduring such hardships and high risks. But being a buddy was not consistent to being argumentative 100% of the time with someone. Especially someone so well known as a heroic problem solver as Improy was. They decided that Stable was a hypothetical "King de-poser." Trying to pick a fight to get rid of someone, to become "King" himself. He did not understand that there was no place for a king-function here, it would just jam up the works.

What to do about this guy? Improy said that they needed everybody, and that there was bound to be some people who disagreed sometimes; they came from different backgrounds. And a diversity of backgrounds was needed to have the best range of possible solutions when new problems came up. "I think the guy is probably a game-player and bored. Some people like to play chess or card games, and need someone to play with. I will just ignore the bait, and he will get bored with the thing and stop messing around. We are all in this together" Improy said, dismissing the whole thing from his mind.

Catalie decided that maybe the guy could find a sense of accomplishment by setting up a recreation facility for playing card and board games. So she headed over to the shaded side wheel, looking for Stable, guided by the computer occasionally. What she found after a while, is that the guy may not have technical savvy, but he was really good at not being found. Every place she looked that the computer had registered Stable was at, she would find he had just left there. Recalling a game she had played when a bit younger and unattached, she imagined she was attractive and needed a hunk right away; and she stayed put. It was mere seconds before a huge man, more hunk than she had ever seen, casually strutted

by, apparently not noticing her while he casually flexed his biceps and adjusted his clothing a bit while in view of her. "Hi! Say, could you tell me if someone might like to set up a game room over here soon?" she asked the hunk. "We need a recreation room like that, so some people can relax and have fun at breaktimes." He turned and walked over to directly in front of her, looking down on her so she had to bend her head up to face him in response.

Chapter 20 Integrating a captive bully

"Are you someone who would like to volunteer to set up a game room around here?" Catalie asked, continuing on the original theme. The huge man continued to stare down at her for a moment, poker faced, unreadable. Then he asked "What is a game room for?"

Catalie shifted mental gears quickly, then replied "A game room is an area where people can go to relax in a special way. There, they have access to board and card games with which to have a structured interaction according to a few rules, during which each player attempts to be better than the other players. Some people find that stimulating, a relaxation from the difficult pressures of a job." Then she continued, "It is a friendly harmless way in which people can find out who is better than the other player, or players, at doing some interactive symbolic activity. It is something that your ego can have fun doing, and the results are not physically real, so the losers are not really hurt. Those who like to play games mostly enjoy the interaction with the other people, with the scores of the current game just something to pretend is important to their ego. Some games play for pretend ownership of property, too. The games all are designed so there are random factors which distribute the starting values for each player during each phase of the game, so that the results of playing the game involve both luck and the skill of the players." She paused, noting something in his expression ever so slightly revealed, then continued "Luck means random factors which happen to make it easier for you. And 'bad luck' means the random factors make it harder for the player to win. To win means to demonstrate that one was both better at playing the game and had good luck in that game play." She

stepped back, turning, saying "I'd like it if you would think about this volunteer task, and you can read up on the description more on the network under 'games'; then in a few days send me your decision though the network. I am Catalie, what is your name, so I can watch for your reply?" He was looking a bit interested as he said "I am Stable." Walking back toward the nearest spoke to the hub access to the other wheel, she was partly turned as she said, “Oh good, I sure hope you will do this for me, this is something that would really help people relax over here."

Back in his quarters, Stable evaluated the new information. Up to know, he had easily sidestepped getting hooked into doing one of those stupid volunteer jobs, yet had a fine place of his own and plenty of food at the cafeteria. Yet, he had noticed that other people's egos were stronger when they were doing their stupid volunteer task well. But this volunteer job sounded interesting, a "game room" which he would set up and be boss there, and always be able to play games to show these guys that Stable was better than they were. It did look like he might have to actually learn how to do the game thing instead of surfing and skittling through things ever faking everybody out. But the games were not real, he said to himself. Even failing did not mean something bad, in reality. The whole thing was intriguing to him. He made his way to the nearest computer terminal, and for once was not there just to examine Improy's latest postings, but instead to look up the description of "game."

He found that there were too many things called "games" for him to gather them all in; there were sports games, card games and board games, each of which had a variety of rules and things played with as symbols of things to own and trade, or lose as a result of circumstance, and symbolic territory to be gathered

or lost. One's position on a game board was meaningful too, often it involved traversing a path to reach its end before the other players did. This was looking real interesting. The losers would have to consider him better than they were, right? She had said something about card games and board games, that narrowed down the search a bit. Still, there were lots of both kinds. And each required some special equipment, such as decks of cards, poker chips, specially made game boards and game pieces, dice to roll, spinners to whirl, to establish luck. So he would have to get those things, and learn the varieties of rules for each. He could pick the games, it was to be his game room, so surely he could do that. The game called "Poker" looked like a one to start with, since it only required the making of a deck of cards, which ought to be able to be done on the computer printer; and the game of trying to guess the cards the other players held, was something he could do psychically, and in fact would have to make deliberate errors at times so others could win occasionally. He would only win the really important games, and in the meantime he would be finding out how the other players minds worked. that would be something that always comes in handy when the real action starts in the real world.

When Catalie received an e-mail message from Stable, agreeing to take on the volunteer job of setting up and running a game room, and requesting assistance for making a deck of cards, she commented to Improy that progress was being made regarding the incidence of "rivalry" that had been going on. She said that the guy had used a computer terminal for something other than provoking contest with Improy, in that he had searched for information about a subject on the network, and seemed to be taking an interest in doing something contributory on the station. And, she asked Improy if he could figure out how to make a deck

of cards. They had no cardboard or paper up there, no printers, and no deck of card images from which to print even if they did. Already knee-deep in problems to solve with too few resources, he asked a bit exasperated if a deck of cards was really necessary. "If you want to begin to tame a dangerous wild beast stalking among us" she replied, "a deck of cards and poker chips might be easier to fabricate than having to fix something destroyed in a worse game."

Improy found that there had been a standard set of cards for a lot of different games, and the one used in Poker was the same deck as used in a game called Solitaire, for which there was a set of images in an old computer game software. There were cards 2 through 10, a special number one card called an Ace, and three hierarchical people cards. And there were four distinct. sets of each. He had some left over spacesuit flat sheeting which he cut up into playing card sized chunks, He had a co-worker write the names of the various cards on the chunks of flat material, such as "Ace-Spades" and "Jack-Clubs." If the thing got popular, maybe they would try some images on the cards.

Chapter 21 Test and see if it works to do the job

The accumulating knowledge base stored in Leo Island's distributed computer network put out a request for descriptions of how to play card games of various kinds, including Poker and Solitaire. Stable was then sent e-mail showing where this information was. He was also invited to put an announcement online about his game room with its games available, when he was ready to host the game room.

Stable was intrigued with this idea of him having a game room, where people could go to test who was better than whom. He himself could then show these people who was better at games than they were. He also hoped to find companionship there, in a hierarchical system based on who was better; that was something he could understand. The system being used here in Leo Station was defined on who did what job and when doing it, instead of who was better than who; and that made no sense to him since it was not based on who was boss of whom. The idea of "games" felt comfortable to him; and despite his powerful physique and inbred ability to stalk and assault, he felt very much alone here, far from the Ownma people from which he had sprung, even though they had disowned him and considered him dead, destroyed as inferior genetics were always destroyed in Ownma's eugenics program. Among these Employee type of people up here, he felt that he ought to be supreme boss. But these people did not understand "boss" so it was a bit of a problem for him. Now at least he could be boss of the Game Room. And see where that would lead him.

Eventually Catalie mentioned to Improy that the series of votes that were in exact opposition to

whatever Improy voted for, was sometimes not appearing on the voters readout of the day. It appeared that Stable was sometimes too involved with his Game Room activity to bother with the opposition effort against Improy. Hopefully the Game Room was providing him with a feeling of being a "king" of something.

Meanwhile, the dual directions of preparing for an exodus from the space wheel station, while also preparing for permanent habitation in the space dual wheel, was making progress. They had created a modularized exodus spacecraft design, so that as they came up with better versions, it was fairly easy to upgrade the spacecraft already built, to match the latest one's design. They began to use the computer network to do some of the routine chores in the agricultural area, using actuators to switch nutrient flow based on the various agricultural subsystems needs, while referring to a projection of trends in the needs of the station for food production and hydrocarbon organics recycling.

Since it was essentially a closed ecosystem of materials, powered by the conversion of sunlight short wavelength energy into long wavelength radient energy sent into the darkness of space by the heat radiators, materials were increasingly considered as something that merely was transformed from one form to another within an overall cycle that returned it to its original form. Use of the terms "waste material," "garbage," and "recycle" faded away, in favor of the terminology of the transformation series of forms of closed loops of material substances.

The transformation series of nutrients generally was separate from that of the industrial processes. The metals involved in industry tended to be toxic as a

nutrient, so it was easier to keep them separate from food preparation discarded material, instead of having to expend energy to sort the metals out later, usually by the use of the huge solar powered mass spectrometer element extractor. Small adjustments to the radial distance from center of rotation of the wheel, as measured between the ends of liquid flow tubing, provided a simulated downward flow that moved the fluid material along at an optimum rate. That minimized the need for pumps; and pumps took much more effort to build than making a centrifugal force gradient along piping. Although their population of 1,145 was gaining capacity for accomplishment by the education system built into their daily work life, there were only so many people to do some particular thing at any given time. In general, the less effort it took to accomplish a function, the more desirable it was among alternatives.

Keeping people's spirits up was considered a prime function of their system, ranked in priority about equal to having adequate nutrition and safe, comfortable shelter in which to relax. And as with the improvisation they had to do regarding nutrition, so also they had to improvise on how to keep the spirits up. That everybody had a mate, was the prime means of keeping the feeling of well-being adequate, despite the need for some to take on multiple mates to satisfy that need, given the relatively few women they had in the population.

There was quite a variation in what the various temperaments among them required for a sense of well-being, and so similarly wide the diversity in the facilities and techniques that needed to be defined, set up, and operated. The Game Room had become an instant popular activity, despite the imposing operator of the facility who seemed to ever be watching them playing the games, almost as if getting into their minds.

The general philosophy of "test-and-see-if-it-works-to-do-the-job" that was working so well on technical goals, was applied also to the "well being facilities" of which the Game Room was the first. Adjacent to the cafeteria nearest the Game Room was setup a nightclub kind of facility, where people could go to socialize while also having some nutrition and watching entertainment. Some temperaments of people especially enjoyed this kind of thing, while other temperaments did not particularly enjoy it, but could endure it for awhile. Ethyl alcohol was biochemically produced and added to beverages, as part of the nightclub atmosphere; from the beginnings of civilization, alcoholic beverages such as beer and wine were utilized as a uniting force among diverse people, and was especially important up here to create a relaxed uncritical ambiance. A few people had some musical skills before their capture, and they formed a group to entertain at the nightclub. At first, they utilized existing objects that would ring resonantly and be tuned to some extent. Then some of the nightclub patrons volunteered their craftsmanship skills to make resonant objects that more nearly resembled conventional musical instruments, making it easier to play them and to provide a wider variety of compositions they could play. It was always "Amateur Night" every night at the nightclub.

All these activities and techniques were documented in the growing database of the computer network continually available to all. Drum design was recorded as it evolved from beating rhythmically on shipping containers, to better designs; Xylophone-like instruments were made with cut lengths of tubing, and ever refined as to tuning frequencies. People began to absently tap on resonant objects in their workplace as a relaxation technique while on the job, helping maintain their mental balance.

Electronic musical instruments were simulated by use of the omnipresent computer terminals, and software was written so that anyone could create a musical composition that the computer would play for them, and a "perfected" composition would be saved by the person as part of the universal database. It became a new "well-being" activity throughout the station, some people writing waveforms that simulated surf sounds on a rocky beach, as best they could remember them; even simulating the calls of larger animals and birds from their memory, and other sounds familiar to their free life on the Earth's surface so many years ago. Yet also the construction of resonant surfaces objects, tuned filaments and pipes continued to be used, as it stimulated the tactile-kinesthetic part of music; this then expanded into dance forms. Well-being was increasing.

Yet the stress of having to both strive for permanent residence here, while also striving to prepare for abandonment of the station in an effort to return to the Earth surface, reduced the general sense of well being among them. Votes were taken, and it was still decided to complete the construction of enough return spacecraft for all of them and their agricultural animals, mothballing the spacecraft along with detailed plans for their usage in case it became necessary.

Dreaming and planning of the procedure for establishing a way of life down there, would continue to be accumulated in the database. Their receive-only access to the earth's internet system indicated that the stranglehold of the rich-elite owner-managers of the huge corporations ever increased the separation from them and the employees who did the work and lived in increasingly difficult ways. The planetary ecosystem had deteriorated so much that a quarter of the previously habitable areas had become unsupportive to life, making it even harder on the vast majority of

working people. So they used their telescope oftentimes to search the uninhabitable areas, trying to determine what caused the ecosystem's dysfunctionality at each place, seeking places they might land and use their skills and techniques developed up here, to a new life down there, far from the iron fist of the corporations.

They again modified the design of the basic return spacecraft vehicle, to seat only four people each, have pens for a few animals and seed stock, initial food supply and water for a month for all, and computer linking by tight beam. The thought was that the vehicles would return to the ground all near each other as possible while landing safely, then use the vehicles as homes for the four people in each one, while they set out to create new long term living space on the ground. So the vehicles were designed both for a safe and piloted glide landing, then be used as a starting point for building their new homesite.

Dreaming of how and where they would do this was a preferred pasttime for those who were finding it sometimes difficult to cope with life on the space wheel station. But most people found it uncomfortable to do this part of the planning, while their daily lives were spent in getting the wheel's environment to work together for all of their continued long term existence, and reasonably well.

Chapter 22 To stay or to go back

One of the recreation rooms had snacks, beverages and displays of earth internet news items. It was receive-only, since they could not risk it being known that they still existed up here. It was one of those times when someone was idly watching the news from below, while munching a quail & cockroach burger, that the news was announced. The mega-corporations had finalized their ownership of all that remained of civilization, and that henceforth the delineated territories of each of the mega-corporations were not to be crossed by Employees. And there was now an over-arching mega-corporation which also had the American territory formerly called Ownma Corporation, but now the new super-corporation was named TANFL, acronym for an old motto "There Ain't No Free Lunch" which was to be the guiding motto of the new organization. Everybody had to pay, or more correctly, every employee had to pay for everything they wanted, but the TANFL people did not, as they were all floating in the unimaginable riches of the corporation, and there was no need to do accounting of the little fraction they spent on their personal needs or adventures. Every Employee had to pay, and that meant they had to work for the Corporation, and accept the pay rate set by TANFL. There was to be no charity among the Employees, so there was no respite in case of simply inadequate pay rate or intolerable job assignment. No work, no pay, no food or shelter. The Employees must also pay for the disposal of those who starved to death in the street as a result, or froze to death without shelter, so as to keep the streets clean of those bodies.

Soon the news spread in the space wheel station about the turn of events down below. It was shocking to most of them, even those who had seen

that kind of thing as a trend from long ago, the separation of the rich from the workers, a disappearing middle class. Now there was no middle class at all. And there was no social vote mechanism for reversing the class-based system.

Up here they had proven that people could work together to provide a safe home for all, retaining each person's individuality, and inviting the best from each person. They had created their own Corporation, one that was guided by product instead of profit. They each also being a consumer, the products filled their needs as best possible in the balance of all things. Everybody worked, none were the idle rich because there was no wealth to accumulate. Instant education to every person for any task, via their own version of the internet, along with the pooling of each person's knowledge and daily data gathering re the task being performed, built up the knowledge database. It was working for them. Why wasn't it done down below? Everybody up here lived much better than the Employees down there, and the resources up here were so very limited, in the dual space wheel that was originally outfitted to be part experimental station, part prison, a very difficult starting base. Surely despite the deteriorating world ecosystem down there, their Emplos kind of Corporation would provide a better life for everybody. Surely even the Rich Elite Owner-Managment class could find adequate pleasure without having to brandish their vast accumulated holdings as status symbols, they thought.

But then the people began to remember that the Rich-Elite had been long in a super-race eugenics program, and no longer considered themselves of the same species as the Employees, and that really altered their thinking patterns. It was comparable to the way the agricultural workers saw themselves different from

the fish and goats they tended. The Owner-Managers were like the agricultural workers who tended the fish and goats, like the Owner-Managers tended the Employees. Not of the same species; and effectively had the power of life and death over them, without need to answer to anyone.

They all had loved ones down there. Catalie and Improy thought of their daughter Idealiana being crushed into some mold in that system. Surely there was some way they could help their loved ones?

A month later, a vote was called. The result was that they would initiate their Exodus, down to where they had a chance of helping out. They did not know how to help, but they knew it could not be done from up here, so vulnerable from even one warhead sent up in irritation by the TANFL Corporation, if they got to be considered a nuisance.

The accumulated musings on the subject were called up from the database. There were several places that had been abandoned by the corporate holdings as the environment had died; and the Corporations owned all the land that was habitable profitably.

More serious thinking was done on how they would survive down there, on their own as much as they were up here; and without the resources of endless solar energy and zero-g hard vacuum for materials processing, so essential for their survival up here. Much of the space station had been long in computer assisted mode, and it seemed possible to further modify the station to be a self-operating system for some time after abandonment by people. They decided to build microwave power beam generators to beam down the surplus solar-derived electical energy, no longer needed with the people gone; and they would

remotely control the directing of that energy beam to lock on their sending antenna location, which would be in the middle of a rectenna they would build, so they would get a burst of electrical power everytime the station was within beam range, day or night or stormy, they would get these dumps of electrical power, that they would have to store somehow, and use on the spot in some processes.

They also rigged a link to direct the station's telescope at some location on the ground, and relay the digital images down to them. Meanwhile they continued to use the telescope up here to determine what was happening down on the surface. Where had Ownma gone, now TANFL Corporation? Repeated examinations of their launch site, Ownma White Sands, showed no sign of activity. It appeared to be abandoned a long time, and the desert was beginning to reclaim it. Sandstorms had drifted sand across the highways in places, and no vehicle tracks had left marks of passage across the sand drifts. All the cities in the area had been abandoned even before they were launched up here, as water became uneconomical to bring in there anymore, the water table fallen beyond recovery for even drinking water. In fact, if they ever hoped to be able to return to the wheel space station, it would have to be from White Sands, as the only boosters in existence were there. The landing strip that had once been used for the returning boosters that had lifted them up here, looked like a reasonable landing place for their return spacecraft gliders. Holloman airfield was not far from there and could serve as a secondary landing runway. Even the abandoned highways could be used in a pinch. They really did not know what difficulties would be encountered when making an unpowered landing down there.

The entire fleet of return spacecraft was inspected for inclusion of the latest modifications, and their basic provisions were refreshed. Their wheel population was divided up and assigned a spacecraft; as much as possible, whole family groups were sent in the same return vehicle, as they had already worked out their own internal team spirit among themselves long ago. Volunteering rosters were established to show who preferred to go among the first, among the last and in the middle to go. Improy and Catalie decided they probably were better able to guide the exodus from up here, at least until it was certain things were working reliably and smoothly, so they resisted their adventurous urge to go first to deal with the unknowns of landing. They chose randomly among those who had wanted to be among the first to go, based on their recorded skill in the landing training simulations, and their observations of them on the job up here, especially in highly stressed situations.

All the people in the station gathered around the larger network computer displays to watch the embarkation. The family crew members wore some of the few "cockroach" spacesuits that had been manufactured, as better protection during the re-entry stresses, although eventually most of them would enter their own vehicle in ordinary clothing, it was hoped. The spacecraft's nose hatchway was sealed, then the Embarcadero's airlock was sealed, and it was on camera for awhile as the spacecraft coasted away far enough for the nose cone to swing around and latch. The initial electrically driven thrust was delivered to the vehicle along an acceleration ramp backward along the stations's trajectory, slowing the vehicle in the orbit, and the tether ribbon's slack was soon taken up. The slight gravity on the spacecraft, going slower than the required angular velocity to be in orbit up here, reeled out the ribbon at first slowly then faster until an

optimum decent velocity was reached, then they used dynamic braking to maintain the decent velocity. Their "human gyroscopes" were practicing pointing the spacecraft around into various attitudes, gaining a little more skill at this once sport activity.

The next day the tether had reeled out sufficiently to start slowing the decent rate on the spacecraft, and the human gyros were getting some practice at adjusting the spacecraft's attitude while also experiencing some weight, almost 1-g. Then the tether was allowed to unreel to the point where there was significant drag backwards on the tether, as indicated by the drag airscoops propellor rate instrument which was mounted a little above the spacecraft attachment to the tether. They practiced more at their gyro attitude adjustment, and measured the small amount of airfoil control surface effect on the spacecraft's attitude while being towed by the tether ribbon cable.

It was a tense moment for all. The spacecraft sent a radio signal up indicating they were going to commit to launch. They tilted up until it showed their lift supported their weight, and they activated the release latch. From there they had nowhere to go but down. Suddenly no longer towed forward, there was a sudden small jerk but continued with the same attitude; they went into almost free-fall again, building up velocity. A noticeable sense of slowing and direction of gravity built up as they maintained what they had guessed was the optimum angle of attack as they went deeper into the thin upper atmosphere. They experienced a little over one gee as the gliding spacecraft bounced back up on their first skip. They continued to skip up and down the upper atmosphere, slowing down some with each bounce. Having gone entirely around the planet, as judged by terrain below them at time of release from the tether, they sent a brief radio signal upward to the

space station that they had gotten this far, looked promising. The cabin temperature was quite tolerable, as the craft's large airfoil glided them down so slowly.

Then the next critical phase began, as they made the last circle around the planet and swung into a large circle, remaining above the area where there were no people, staying away from the California coastal area where Ownma/TANFL Corporation had retreated to, gliding around and around, breaking the sound barrier as slowly as possible, keeping the heating down as much as possible by coasting, circling White Sands. Their pilot used the reflexes trained in the simulator, although the simulator never had produced the forces pushing one's body around during the moves, quite this way. Expecting that distraction, the balance between losing altitude, holding above stall speed, and orienting to be lined up with the landing strip's end when it all went to zero, and they were down, skidding along the runway.

They had no landing gear so there was no steering wheel for the ground guidance; the pilot called out "Everybody lean left! Everybody lean right! Front half lean left! to slightly influence the attitude of the vehicle as it skidded on its belly along the runway, slowing much too slowly without either brakes nor drogue chute. Off the end of the runway into the sand, they slowed much faster, then with a twist, they were stopped.

They sat there, only popping open their seat belts, while their heart rates slowed down. The pilot pulled the spring release that threw the nose cone around its hinge, then cranked on the airlock dogs, and opened the hatch to the bright New Mexico sun. Filing out through the nose hatch, they went over to the shade of the nearest building, and proceeded to have

their snack prepared for this event, which included a bit of ethyl alcohol with which they gave a toast to their safe arrival.

Their first duty was to split up into twos, and go search to verify there were no other people around there, and no security cameras announcing their presence. They had shed their spacesuits in the landing craft, so they looked reasonably normal, they hoped, in case they were on somebody's camera. The place seemed long abandoned, probably since the last load of prisoners was launched on a one-way space bus up toward the space station, several years ago. They followed the security cameras' cables to the security control room, which was found open, its door swinging back and forth in the wind gusts. All power was dead in there, but they methodically disconnected every connector they could find, then closed the door as they left. The electronics in that room would be valuable to them later, no doubt, for other uses.

Checking the time the space station would again be in line of sight while also not in the direction of any known habitation, they set up their dish antenna; and when the station was expected above, they transmitted the safe landing coded message up. And immediately received a coded acknowledgment beamed down to their location. It was done.

Chapter 23 Escaping back to Earth

Their next need was to get their landing spacecraft off the runway area and make it less conspicuous in case some TANFL aircraft, if any existed, flew over. There still was a partial circle of spare habitat modules over in the site where the modules had been set up and tested for systems integration as a living system within a machine system, before disassembly for launch of the individual modules into orbit; if they could get their landing craft over into the circle, it would be less conspicuous.

Half the team took on the task of disconnecting the 10 meter diameter 20 meter long cylinder of the return module, that was built also to be their home for an indefinite period down here, from the cast aluminum foam wing and re-entry shield and landing skid underbelly.

The other half of the team went to one of the trucks that were used long ago to move the habitat module cylinders around, and to bring them to the launch pad assembly area. There was plenty of the pulverized coal fuel for the truck, and it was not long before the external combustion engine's flash boiler was belching black smoke as it began to bring its power systems back to life after several years of sitting idle in the desert. Its steam engine was in a totally enclosed loop through the turbine and then to the waste heat radiator, so it still had its liquid boiling fine inside, and it began to rumble off toward their landing craft. Its pair of transfer cranes swung around and belts slipped across front and back of the cylinder, now disconnected from its landing airframe casting; then the module segment was on the truck, and soon headed toward the partially finished ring of habitat modules. The module was set

into the ring groove, although since access to their home was through one end of the cylinder, it was not placed up against the module there, so they could get in and out of their home. There was plenty of empty room on the ring for all the landing craft coming back.

They explored the remaining arc of habitat module space station segments, which appeared to be part of a third ring for the space station, but its construction had been halted and abandoned. It appeared to have been being built as another prison type facility, but it included two of the agricultural sections and a cafeteria section, although not set up yet to be functional.

The next time the space station was passing by overhead in its orbit, they sent up a message in its direction, saying that their return vehicle had been cleared out of the landing field and it was ready for the next landing; and also told about their discovery of the partial habitat module wheel set up which included agricultural areas and cafeteria, so bring down as much agricultural materials as they could stuff safely into their spare room. A coded beep message was sent back from the space station, indicating receipt of message.

It looked a lot easier to get the agricultural sections and cafeteria going in the partial habitat ring, than to set up some place there in the open desert to do farming to grow their food. The wheel station's agricultural area was designed for complete recycling of water, and water was going to be one of their critical shortage items.

They had brought down only enough food and drink to last them for a month, so they had to have another nutritional supply source going by then. They put their organic waste material into one of the partly-

finished wheel's agricultural areas; the material would be almost as precious later for agriculture here in the desert as it was up in the space station.

Meanwhile, in the dual wheel space station up in Low Earth Orbit, The second return spacecraft vehicle had been brought out of storage and prepared for boarding by its crew. They had studied all the data sent by the first vehicle's crew during its pioneering decent, yet they knew that their trip would also be sprinkled with unknown variables encountered along the way. There was no way of knowing if the first landing had been through good luck circumstances. Weather was a variable quite risky, and although their telescope was able to see if sandstorms and storm clouds existed before launch, it could not see nor predict gusty cross winds existence. Once committed to the tether drop, they had only one day extra air reserves to hang down there in the fringes of the upper atmosphere while waiting for weather to clear up down below; and of course, if weather turned dangerous while they were in the atmospheric decent, they were committed to go down somewhere, one place or another, gently or not gently.

The Earth's weather had long ago turned sour from the global warming greenhouse gas accumulation, but there were still some seasons of relatively calm weather in the White Sands area, one of which was occurring now. They needed to get the vehicles launched as fast as possible to take advantage of the weather window for landing reasonably safely. They prepared to do a launch every other day, which allowed half a day to bring a return vehicle out of storage lashed to the hub, dock it to the Embarcadero's airlock, finish its nutritional provision and clothing stocking, load agriculture and some light industrial machinery, passengers and pilot, send it on its way by tether, a

controlled drop which took a day at least; then a half day to reel back in the 230 miles of emptied tether, damp its oscillations and connect it with the next landing spacecraft. It would take two days at least for each vehicle.

The second return spacecraft was lowered on the tether; they practiced their attitude control while dragging lightly along in the upper atmosphere, released from the tether and began the skip-and-bounce around the planet with their large foamed aluminum wings, keeping re-entry cool, until they slowed enough to circle White sands, and then they too were skidding down the runway to a stop in the sand beyond its far end. They got greeted by the crew of the first vehicle, and they all went to the shade of the nearby building and had the now somewhat traditional toast with a cup of ethyl alcohol in juice beverage.

The module carrier truck belched black smoke again as its coal-fired flash steam turbine engine spun into life, and within 4 hours the new module section was placed near the first one in the empty part of the habitat ring cradle in the desert floor. They moved the agricultural materials out of the module, which included some chunks of grain growing in its matrix, and put right back in the equivalent area of one of the agricultural areas of the abandoned modular habitat ring section, ready to resume growing now in the desert sunshine instead of that of earth-orbital space. A few quail were brought along too, a start on a new flock down here, a start again at providing a bit of eggs and meat. And of course, some caged small cockroaches that were so essential for both recycling of organics and providing protein nutrition supplements for both the quail and people.

The agricultural matrix was activated with their liquid organic waste materials as much as possible, and the returned grain sections were used as starts along the matrix, along with seed planting, so as to provide a harvest distribution.

In the first two weeks, they had landed the first 5 spacecraft return glider vehicles, so they had 10 of the extended families and enough agriculture to have a chance at long term sustenance of themselves. The calm weather seemed to be holding up OK, and the vehicles were coming in at an average rate of 1 every two and a half days; not all went smoothly and so took a bit of extra time.

From orbit in the space station, it could be seen that weather was getting ready worldwide to begin another stormy season that likely would reach White Sands facility area too, making landings more risky. They were sending down groups of the extended families. Since the population had been only 25 percent women overall, mostly each one had several husbands, which created an extended family. The members of these families had traded around from the original random assignments until each was in comfortable balance as a team. Some of the original space station wheel's crew were already couples of just one man per woman, so the remainder of the women had three or four husbands, making a typical extended family of 4 or 5 people. Each return vehicle carried two extended families, so the dual wheel's population of 1,145 people needed to launch 128 of their space return vehicles.

Improy decided to convert the tether into a full loop, leaving the drag airscoop down in the high fringes of the upper atmosphere, swung on a pulley. This way, as one spacecraft was lowered by the tether, tether material from the previous launch was being lifted up to

get another vehicle. It took a week to make this modification, during which no vehicles were launched. When a test of the loop successfully lowered and launched the 6th return vehicle, they began to launch a vehicle about every day; then they tried lowering two vehicles spaced evenly on the tether, thus launching a return vehicle every half day, 14 each week. This clearly was not going to get them all down before the stormy season, so they lowered three vehicles at a time on the tether; but the winch motor was showing signs of overheating when they tried lowering four vehicles at a time, so their limit was three vehicles per day with that system.

Improy and Catalie were having to troubleshoot and solve technological crises that were going on in the space wheel as the evacuation of the wheels got into panic mode due to the increasingly dangerous weather down there at the landing site, so they were staying to be on the last return vehicle. Already they received some reports of vehicle overturnings as they skidded down the runway in gusty winds, destroying their foamed aluminum wings in the process, scattering the pieces around, and generally shaking things up inside, particularly the agricultural supplies and the equipment too hastily stowed.

The process of disconnecting the foamed aluminum winged re-entry sections from the cylindrical section, and hauling them over to the module ring, was already overloading the ground crew and single crane-equipped truck, so several of the crashed vehicles had to be left where they had stopped, although they had been up-righted by the crane so the occupants and supplies could be gotten out more easily. It was a big area, so it was unlikely a vehicle skidding in to the sand portion at the end of the runway would strike one of the crashed vehicles; but not impossible.

Improy and Catalie stayed to operate the tether for the last of the return vehicles lowering and release into the upper atmosphere. There were still a half dozen of the return vehicles remaining. Improy modified the RF link between the station and their descent vehicle, so that the winch and emergency release latch could be operated from the vehicle as it was being lowered. They went around the station wheels, verifying that the telescope could be controlled and viewed from the ground, that the solar-derived power beam was locking onto the target transmitter on the ground and was pouring out microwave energy at it during each pass over the White Sands area; and they verified that the internal mechanisms were all working well, including the robotic operation of the remaining agricultural area they had not been able to take down with them, to keep them alive as long as possible. The remaining agriculture consisted of the grains, some vegetables, cockroaches and a few quail families. The rest had been taken down to the surface already.

Improy and Catalie loaded up their return spacecraft, including use of the unused passenger space, lashing supplies and one of their space worksuits into the unused seats. Manually closing the Embarcadero's hub airlock hatches, they then sealed the nose entry hatch. Verifying the tether was properly attached, they allowed the craft to release from the dock, unlatch the spring-loaded foamed aluminum nose cone which then swung around and latched into position for the flight back. Then Catalie sent the signal to the winch to start lowering them, and away they went. They took turns doing the "human gyroscope" practice at orienting the attitude of the spacecraft as it was being lowered. Neither of them were very heavy, so they had to work at spinning around quite vigorously; the other descending vehicles all had had someone who was tubby yet athletic to some extent, and they

had done the gyro attitude control. So they took turns, Catalie being the pilot calling out attitude numbers, while Improy cavorted in the center area being a gyroscope for awhile, then they would switch positions. When they reached the pulley bottom end of the bi-directional tether, they sent up the signal to stop the winch, and go into long term standby mode. Improy wanted to make it possible for a vehicle to fly up here and latch onto the tether to return to the space station, if that became possible and useful in the future.

They used the airfoil control surfaces and last bit of gyro activity to optimize the attitude of the spacecraft, then they released the clamp, and they were free and headed toward the planet. They repeated the long slow bounce mode of skipping across the upper atmosphere, gradually slowing the vehicle down without heating it up intolerably. This kind of re-entry had very much less kinetic energy to dissipate than a vehicle would have if de-orbiting from Low Earth Orbit altitude, since they were traveling with the same angular velocity as the higher station yet were not dropping except from a start in the upper atmosphere, instead of plummetting into it from hundreds of miles above in free-fall conversion of potential energy into kinetic energy. So it was relatively easy to cooly lose their kinetic energy and altitude potential energy, encircling the planet a couple of times gliding on their big swept back wings. But there were scattered storm clouds over the White Sands landing area. Catalie strapped herself into the passenger seat nearest the pilot, and Improy piloted the rest of the way down. He could see parts of the runway through breaks in the clouds. He circled until it was time for the space station to be overhead, then he sent up a command to temporarily cut the beamed microwave frequency to a wavelength that would be absorbed by the cloud water droplets, and fire the energy beam toward the rectenna targeting transmitter location near the landing strip. In

two minutes a hole had opened up in the clouds, evaporated by the beam from the space station, then the station was out of range. But there was a lot more of the landing strip visible now for a minute or two, and he dove toward the end of the runway, coming in a bit too fast. They skidded on their foamed aluminum underbelly, Improy using the airfoil control surfaces to keep the vehicle horizontal until too slow to be guided by deflection of air, then they spun to face the wind, skidded a few yards more, and they were back home on Earth once again.

A welcoming reception greeted them as they emerged from the nose hatch, getting them over to the traditional building wall for the toast for safe arrival, though the wall was now a wind shelter more than a sunshade. Others emptied the spacecraft of its precious cargo and took it to the ring of modules. The crane truck was not to be brought out until the storm had died down enough to safely lift and position the cylinder to be hauled over to the module ring.

Inside the habitat module ring's cafeteria, Catalie and Improy found a Thanksgiving feast was prepared, awaiting their arrival. They gave thanks for their return to the Earth surface and the abundance, such as it was, that they had; and for their life that continued and hope that they could help their loved ones elsewhere on the planet.

Chapter 24 White Sands revives again

The next day, despite the storm ongoing outside, Improy went out to get started on two projects. One was to capture and store as much of the currently downpouring rainwater as possible. The other project of the day was to get started on building the rectenna to capture the solar-energy derived microwave electrical energy that was being beamed down from the space station whenever it orbited past overhead.

Rainwater was being captured and sent to downspouts from the old Ownma Corp buildings, an easy starting point for gathering rainwater. He and a volunteer crew willing to endure the battering of the storm, searched the buildings for any kind of container that was empty and could hold water, and set them under the downspouts of the buildings. They also put some tarps out that they had found in the buildings, to also gather rainwater and divert it into some storage containers. Some of the crew stayed to move filled containers to places out of the weather, and to empty the ones that looked like really clean water into the agricultural areas, then returned those containers back to where they had been getting water from the downspouts and the tarp's runoff. They needed water to expand the useful parts of the agricultural areas, particularly the fish tanks. And since they would no longer be a fairly closed ecosystem, with people going in and out of their homes and the partial station's arc facilities, they would be losing water to the hot desert throughout the long desert summertime.

The rest of the crew went with Improy to move the energy beam's target transmitter a bit further from their little settlement, then they set up the rectenna sections which they had built on the space station and

brought down during their evacuation of the facility. The rectenna grid was mounted two and a half meters above the ground, permitting freedom to move around under it. Although it was only about ten percent of the full size rectenna array they intended to build eventually to capture most of the incoming energy from the Solar power space station, it was something they could get going quickly. They ran wires from the rectifying antenna over to one of the return modules that had been abandoned in favor of living directly in the unfinished partial space station wheel in which they had the agricultural areas starting to function. The pre-test space station wheels had always been powered by the coal powder flash boiler turbines driving electrical generators, but the reserves of that energy supply would later be more needed to power their vehicles.

They had to find ways to efficiently utilize the brief periods of electrical energy from space. They measured about a megawatt peak power each pass of the space station, varying with the angle from which it was sent. Their few industrial processes that could use DC power directly at high voltage, were set up for this power source first. They tapped some of the DC off to be used in a DC to AC power converter, and voltage controlled it provided conventional energy for their fixtures, at least for 10 or 15 minutes a pass. They set up an electrolysis facility to use the DC current to convert some of the water that they were catching, into hydrogen and oxygen, gathered in separate bags for now. These gases could then be burned later at will for some industrial processes, and to heat a flash boiler steam turbine electric generator that had formerly been powered by burning powdered coal. This was not very efficient, but it did make it possible to utilize the energy whenever it was needed, all the time, such as for interior lighting and operating their computer system and small appliances, any time day or night.

Catalie set up a system that monitored the performance of each of the electrical power systems, creating a data base that could be used to make decisions for what to invest their resources for later fulfillment of their electrical power needs. Improy bemoaned the loss of the prototype Satellite Solar Power Station that had been set up in GEO on the former Space Elevator, as it would have been nice to have its steady electrical power beam to maintain an even supply of electrical energy for their use. Meanwhile, they were thankful for what they were getting from space, such as it was. Soon they sectioned off parts of the rectenna grid, so that during 80% of the typical energy input time, the voltage would be high enough to power a DC to AC converter mounted under the antenna on a support pole, and then send that directly useful electrical energy to the facilities. Catalie set up a sequence program for typical daily needs, so that heavier loads would be connected when the beam was coming in more intensely; then those shutting off while the others, such as lights, stayed powered for as long as enough energy was being received to power just them; this scheme had good efficiency while it ran during each pass of the space station overhead.

Soon they had enough steady electrical power to provide lights, air circulation and the computer workspace education terminals for everybody. This brought everybody back into their familiar linkage with everybody else and with all of what was happening at the moment everywhere, a powerful sense of belonging and contributing. Their Emplos Corporation was now revived in the new setting, delivering the knowledge needed to do each task at hand, and instructions for simulating the skills that would be needed for the next job coming up for each person. Knowing how they each fit into the big picture, and the daily voting to adjust that big picture, utilized each person's activities well, in a

self-guided group coordination, as the flow of jobs progressed and passed between the people's workstations. They resumed their 12 hour workday schedule, with frequent breaks for relaxing and doing exercises designed to integrate the body-mind system, and chatting among themselves via the computer linking. They had no significant commute to do, which gave them much more time to achieve things.

Most of all, it greatly multiplied their ability to achieve great goals. And they indeed had many great goals they intended to achieve, somehow. One of their top level goals was to get their form of corporate function into action by their kind over in the Employee sector of the mega-corporation controlled world. They realized that such an activity would not be welcomed by the owner-management wealthy elite, probably thinking it an effort to unionize the employees against their bosses. They counted on acceptance when it showed improved productivity by the employees, therefor more wealth for the managers, and so an acceptance.

There was a transportation problem. They were 900 miles from the southern California coastal area into which the TANFL Mega-corporation had condensed as the environment died out from under them, inadequate biodiversity remaining to cope with the increasing toxic loads of civilization's waste products. The space between the two areas was littered with the waste materials of a dying civilization on a dying ecosystem planet, as they coalesced for a last stand. Emplos Corporation faced a difficult challenge indeed, just in getting over there, and then convincing the Employees to take up the Emplos ways, while fending off the hostility from the powerful owner-manager elite who considered the employees little more than cattle to be farmed for profit.

It was not that TANFL Corporation was unaware of the dire overall situation, having had to retreat. It was just that they had from the beginning chosen the proverbial "eat, drink, and be merry, for tomorrow will take care of itself" attitude, ever reveling in their bully-gained wealth, sustained by cunning and brutality; they did not care which. It worked for them.

Emplos would have to be careful not to look the slightest bit like challenging the TANFL elite's position, but only to increase the wealth of the TANFL Corporation. Hopefully that would placate the Owner-Managers, while also improving the lifestyle of the Employees.

And all that, after figuring out how to merely get over there from the White Sands facility. They held a brainstorming vote on how to achieve those things from where they were at right now. They retrieved the photos their telescope had taken of the TAANFL-Employee city from the space station, It showed that the management lived in 3/4 of the city area, yet had very few members; while the remaining 1/4 land area was occupied by the many millions of employees, in crammed living space. They recalled the formal announcement of TANFL that their borders were closed to all outside immigration or abandonment by employees; TANFL liked to keep things constant, made managing easier that way. From space, they had not figured out by what means the city perimeter was maintained; but that it was done so rigorously, was evident. Whatever it was, it surely would make egress by Emplos difficult.

Or maybe not, if the perimeter was maintained merely by limiting life sustaining utility access to just within the perimeter, no way to gain water, power, or sewage processing beyond the perimeter, would make life untenable beyond the border.

The more Emplos thought about it, the more they decided that was the means for maintaining the perimeter of the Employee area, and therefore might be easy to enter from the outside. Those of the Emplos Corporation who had become life prisoners and sent to the space station prison, had their implants removed, thus were non-persons as far as the system cared, thus unable to receive food, water, or shelter, and could not exist for long. But Improy, Catalie, and the others of the original space station still had their ID implants. No doubt as soon as setting foot into the Employees' area, the omnipresent security sensors would identify them, and TANFL would instantly have the knowledge that somehow they had returned, along with what that implied. So, the egress would have to be made by members of the former prison. Nearly all of them offered to volunteer for that task. The ones that were chosen were those who were fairly certain they would have family and friends still alive among the remaining Employee population.

Catalie activated the link with the telescope aboard the space station, and had it send digital pictures of the Employees' part of the city down to Emplos terminal network. What they found was that the occupied city perimeter was an artificial one, probably maintained by the desolation and lack of life support systems beyond the perimeter. So it seemed likely that if they could supply their own water, power, food and sewage functions, they could form an extension along the edge of the existing city. And Emplos people were experts at making an inhospitable place livable, for sure.

Improy and Catalie had been spending a lot of time learning about how to restore launch facilities for the space buses. One purpose was to see if the airbreathing booster could be modified to get high

enough to latch on the space station's tether, if they needed to access the dual wheel space station for some reason in the future. The other was to see if the airbreather booster could be used to transport people and goods over to the TANFL city perimeter. The booster as now configured was a drone, no pilot nor passenger space. And it was designed for vertical launch strapped to a habitat module filled with fuel, and then make an auto-piloted landing after it finished its part of the early launch phase. It was all wings, fuel tanks and huge engines. Unlike the cryogenic fuels needed for the main fuel tanks for the launch, the airbreathing booster used liquid hydrocarbon fuel like JP-4, and plenty of it remained in the underground tanks at White sands.

Not far from one part of TANFL City perimeter were some freeways that were fairly free of abandoned vehicles. So what they decided to do was to reconnect some of the return glider vehicles to their foamed glider wings, use the airbreathing drones to fly in the night to near the city, drop the gliders at low speed to easily land on the freeways, and set up the vehicles as homes and basic survival facilities not far from the Employees section of the city. The first landing would be focused on clearing a larger space free of abandoned vehicles a bit closer to the city for the next vehicles to go here.

They were able to observe the progress of the first landing's crew, using the space station's telescope. It went as they hoped. Then a group of half a dozen more gliders were landed on the newly cleared space on the freeway. They then set up their computer linking by beamed communications between modules, and so a mini-Emplos was established on the outskirts of the Employee section of TANFL City. Progress was being made toward their goal.

When the first foray was made to the edge of the city, what they found was that indeed there was no physical barrier there. It became clear that the Employee section of TANFL city was actually shrinking, as people died from deprivation. The survivors were moving closer to the Rich-Elite section border, as people died off. So the Emplos found the edge of the city was still supplied with the basic utilities of power, water and sewer, but no food. It required an ID implant that was on record as still being productively profitable to the corporation owner-managers, to receive food and thus survive.

So the Emplos team moved into the area which seemed most recently abandoned as the perimeter was shrinking, in the process having to clear out the corpses which had been brought out and left there. It was an unpleasant job but they got it done; then installing their computer linking systems in some abandoned buildings, and setting up their mini-agricultural systems to receive sunshine to grow some grains for food and for their quail and cockroaches, all in a fairly closed recycle system to preserve resources as was developed in the space station. They spent a few weeks there, avoiding any contact with the people of the city, until they had a going system functioning.

They found that the TANFL monitoring of the Employees out here was done entirely by sensors activated by the implanted ID devices in each employee, and did not bother with video or audio monitoring, as far as they could tell. Lacking ID implants, the Emplos people could wander as they pleased, essentially invisible to the Management monitors. They had clothed themselves in clothing taken from some of the corpses they had removed from their new quarters, so they looked like normal people, they hoped, to the average person among the

Employees. And they had no intention of going into the Rich-Elite part of the city, where surely there would also be video and audio tracking of everything that went on.

Eventually they were able to locate trustworthy relatives and friends. It turned out that none of them knew why they had vanished, or even for sure that they were gone. So they were spared the effort of explaining that they had been imprisoned in space, returned on spacecraft gliders and were trying to save the employees ... no, they were glad they did not have to try to convince anybody of such an implausible thing. But what they could do is bring some of their family and friends to observe their setup, their self sufficiency, their terminal continual education workstations, their computer interlinked team. And some of the employees liked that, wanted in on it.

The Emplos foray team had brought along a bunch of spare education workstations, for the purpose of training new people, and so this was done. In the employee spare time they came to learn how to interact with the combined education and productive work method of progress, and some even moved to be near the Emplos group. An old abandoned light industry factory was located nearby so they turned it into their first factory for producing the computer terminals, and for training new people how to use them. It was really popular with the employees and used it for their off-duty recreation time, far more interesting than watching old DVD movies on dying DVD players. Then the Emplos team suggested that the Employees form their own Corporation over here; TANFL philosophy was founded on the premise that Corporations were righteous by nature. So the beginnings of the re-trained Employees had a vote on their newly built computer work-education terminals, and chose to name themselves the "Three Musketeers Corporation."

Chapter 25 Ecuador is the place

The "Three Musketeers Corporation" was an idea that caught on quickly, and became the favorite pastime of the Employees of TANFL Corporation, which seemed to not notice it. The specified workload continued to be performed by the Employees during their daily commute by foot into the vast holdings of the RichElite of TANFL city's Owner-Manager section, which occupied 75% of the city land. The Employees did all the physical labor, the menial tasks, for TANFL. When their daily tour of duty was completed, they headed to their homes for a meal, then headed to the Three Musketeers Corporation areas, which were being multiplied throughout the Employee section of the city. Computer terminal manufacturing facilities were being set up in several places in the Employee section, each one set up and run as a self-managed group united by the integrated education-enhanced light industry workstations network that they were manufacturing.

The Port of TANFL shipping facilities were a part of TANFL that was not within the borders of the RichElite. The port served the freighters that linked the Mega-Corporations that had formed throughout the world, as well as was the port berthing the former aircraft carrier now turned private yacht for the RichElite Owner-Managers. The port's operations were handled by Employees who were being directed via video links by the managers who were in offices over in the luxury part of the city. One of the major trade routes was to Ecuador to obtain bananas, routine daily runs on the powdered coal fueled freighters. The port of TANFL City usually had a pall of black smoke hanging over it, which particles caused widespread lung disease and neurological problems from the mercury and other metal particulates laced into the coal that was burned to

propel the ships, and also to generate the electric power for the city. The pall of smoke was long a part of Employees' life, shortening their life spans a lot. Some of the TANFL Employees were the sailors that manned the freighters, which had the benefit of usually having better air to breathe despite the atmospheric wake of heavy black smoke they left behind them. Management was only interested in the bananas and other commodities they received from the shipping, so the rest of the freighter operations was done by the Employees mostly on their own. The new Employee education-workstation terminals caught on quickly aboard the freighters, and each one leaving the port found itself newly equipped with the new linking network between all of its crew's workstations, crew quarters and recreation areas.

When out of radio range of the TANFL Corporation City, the freighter's were able to occasionally get brief radio communications with the Emplos Corporation people at White Sands, bounce relayed by the space station whenever it orbited overhead. During those times, the freighter's education-workstations were integrated with the ones at White Sands Emplos Corporation workstations, sharing knowledge and enabling chat with new people during the brief time spans, something that was enjoyed by people both on the freighters and at White Sands.

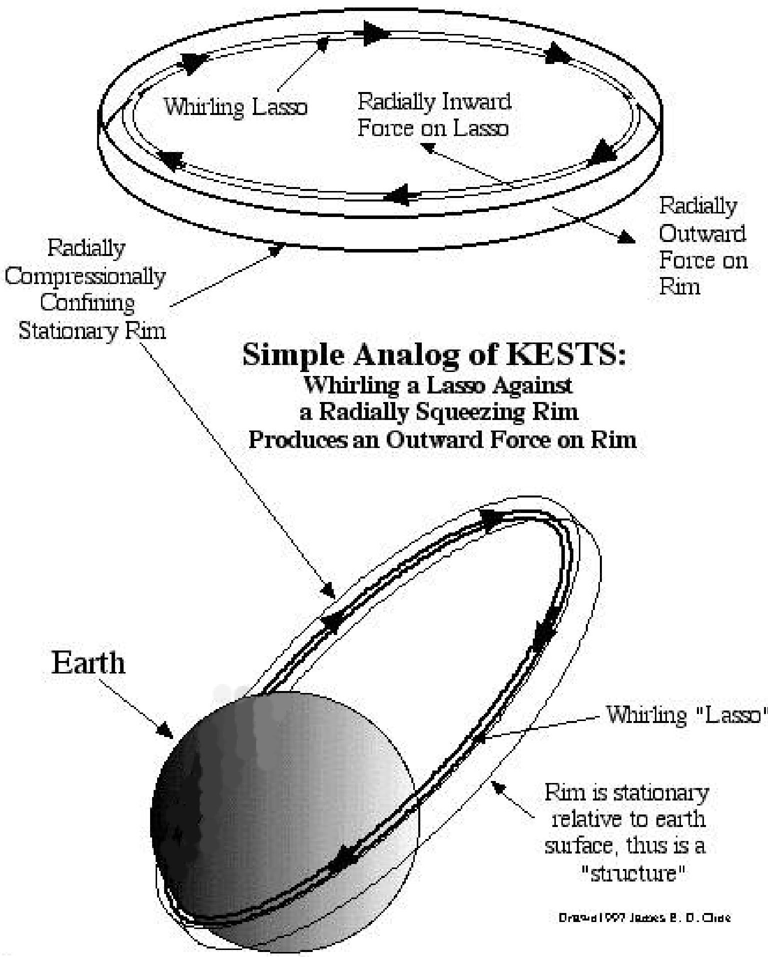
Although the RichElite of Ownma Corporation, now TANFL Corporation, had denied internet connection for the Employees homes, the Employees did sometimes need to access the worldwide internet connection when performing some kinds of routine jobs for the Managers. During the breaktimes while working over in the RichElite section of the city, Employees were allowed to access the internet and play computer games, saving the results on CD's. Some of the

Employees began to download knowledge databases on the internet, bringing them home on CDs and DVDs. Brought on board the freighters by Employees returning from shore leave, the CD and DVD knowledge from the internet was uploaded via the space station links, to the White Sands Emplos Corporation memory banks.

Back at White Sands Emplos Corporation, Improy and Catalie started sifting through the somewhat random areas of knowledge that was being accumulated via the freighter satellite brief links, and organize it into their knowledge network. They were seeking ways to turn around the civilization that was dying along with the worldwide ecosystem it had disrupted too severely. This, too, seemed like an impossibly difficult task, but they were getting used to taking on impossible-seeming tasks, and achieving some significant success at the efforts. What could possibly have such a huge effect to be able to rescue a planet and its human civilization? Catalie found some forgotten ways for recycling and conserving resources, but little that they themselves did not already have better systems for small closed-loop internal environmental life support, developed aboard the space station.

Then she found information on the Space Elevator which they had participated in building and operating a decade past; among the theoretical documents was a description of another kind of transportation structure which did not require the super-strength carbon nanotube matrix ribbon material to build. It had an entirely different technique for providing a transportation bridge between the Earth's surface and Geostationary Earth Orbit. It would utilize a huge hoop which entirely encircled the planet, a hoop which internally had mass circulating sufficiently faster than orbital velocity everywhere along the hoop to create just

enough outward centrifugal force to support the weight of the hoop itself and whatever payloads that were climbing up and down the hoop between the earth surface at the low point of the eccentric hoop, up to the high point which would be in GEO, far above the opposite side of the planet. It had to be built in the equatorial plane, in its simplest version. The writer of



the concept had proposed one of the possible Earth-terminal sites would be anchored in the Andes Mountains of Ecuador.

Improy got excited about this prospect, as it looked like it was something that could be initially built small cross-section and then scaled up to whatever size filled a given transportation capacity need. The upward sides of the circulating mass within the hoop could electromagnetically drag spacecraft up between ground and space, so the energy for transportation was thus distributed all along the structure, so no inefficient lifting of the weight of fuel was used in the transportation process. Scaled up big enough, it could lift the construction materials needed to build enough solar electric power stations in GEO to beam down clean electrical energy anywhere in the world that wanted it. The burning of the petrochemicals could finally stop thereby, they hoped, beginning a turn around of the situation which was finishing off the killing off of the ecosystem upon which civilization existed. And with such a transportation capacity to GEO, they could build larger versions of their mass-spectrometer type total element separator plants up there, with which to convert otherwise unrecyclable toxic industrial materials and byproducts, back to useful pure chemicals again, powered by the Sun. Yes, it looked like they had found a way to possibly turn around the dying planet. And the mountain peak named Cayambe in Ecuador looked like the place to build it. A horizontal tunnel through that mountain in an east-west direction would be the ideal location to anchor the planet-encircling structure, at least ideal in this hemisphere of the world. And Ecuador was a major destination of TANFL freighters, going for bananas.

The Three Musketeers Corporation was also going to Ecuador, but not for bananas; instead they were going there to try to save their planet's life.

Improy and Catalie chose to make a side trip on the way to Ecuador. They set up another of their return spacecraft modules fitted to a set of cast foamed aluminum re-entry glider airfoils, like were used to land the group of Emplos people onto the freeway near TANFL city, but it was just going to be themselves, the space worksuit they had brought down, and some equipment they had built. They were traveling light, because they had to go far and fast. They rigged their spacecraft under the airbreathing pilotless booster which had been fitted for carrying such a vehicle, as well as using its landing gear to take off as well as land later. Improy was going to remotely pilot the drone booster from inside its own payload, then transfer remote piloting to the White Sand control center when they were done with it. They also had modified their spacecraft to have a set of guidance thrusters which had been removed from one of the spare habitat modules, along with the thruster fuel supply.

Strapped into their seats, they readied for takeoff down the runway, Improy piloting and Catalie navigating. The huge turbine jet engines roared into life, brought to operating temperature, brakes were released, and the dual craft leapt down the runway, the booster having much less than the load it was designed to lift through the atmosphere. Quickly airborne, the temporary biplane headed almost straight up, barreling toward space, at the greatest acceleration the two could tolerate. Catalie locked her navigation console onto the signal from the small transmitter they had left attached to the bottom of the tether pulley. It was higher now, having been lifted along with the space station during the dropping of the mass of the return spacecraft

a year ago. Now, they were making a leap to grab onto the pulley assembly as it swung by overhead, tethered to the dual wheel space station far above it. Their timing had to be nearly perfect, and so the onboard computer continued to update their trajectory and adjusted course to optimize that, using its ailerons and rudder. Then the big jet engines began to have insufficient oxygen to continue to run, so they throttled down those engines, unlatched the connection to the airbreather booster, transfered piloting over to the White Sands ground control, and the drone was headed back to the landing strip. Meanwhile, Improy and Catalie continued coasting upward along a section of a parabolic arc that, onscreen, intersected with the path of the dangling end of the tether. Their direction finder kept locked onto the transmitter signal from the tether, and Doppler shift of its frequency gave them relative velocity data. The end of the tether hove into sight ahead of them, then Improy's skills honed on a simulator they had been using for months, used the docking thrusters to nuzzle up to the tether's latch from which they had been last to unlatch only a year past. Now they were again hanging on the tether. They sent the signal up to the space station to start cranking on the tether, bring them back up again. They did some stress relief exercises, munched the lunch they had brought along, and went along for the ride.

Improy had to use the docking thrusters again to get positioned to dock, then they were attached to the Embarcadero's airlock. Improy put their one spacesuit on, and they used a canister of pressurized air to make up for the air used to fill the airlock as Improy went into it and sealed the outer hatch. Once it was sealed, he opened the inner hatch, went into the Embarcadero control center, and normalized the air in there. Then he opened both hatches of the airlock and Catalie came in. They were back home again, at least one of their

homes, they felt. Improy sealed off the airlock leading to the shady side wheel, and normalized the atmosphere and temperature in their wheel, and then made an inspection tour of the facility, particularly the agricultural section, recording how it had fared under automatic control.

The grain had expanded quite a ways into the vacated part of the matrix, and the quail population had doubled in size, feeding on the abundant grain. The cockroaches were as always balancing their population with the available resources. The temperature and humidity were a bit high, so Catalie adjusted the automatic controls based on the time span it took to balance at those higher levels, refining to gradually re-balance at the optimum temperature and humidity. There were enough there to feed the two people for a month and still have plenty of population members to restore their numbers easily.

Catalie assembled the other space worksuit around her, and they went outside again, this time down through the shady side wheel hub airlock. Using material from the huge collection of material from the space busses and supply vehicles, they made the arm for the tether upper pulley into a "V" with a second arm which attached to another de-spun bearing on the Embarcadero's end of the hub.

In the next few weeks they had built another of the solar-concentrator plasma generators like was used in the mass spectrometer type total recycler, and instead of its high velocity vaporized material output going around past a magnetic field, it was just magnetically focused into a reaction beam. They set up a chopper on the space station to methodically cut up the unused section of the space busses, left over from when the return spacecraft were made partly from the

habitable part of the lift modules. These chunks of aluminum tank material were brought down the tether to the plasma generator on the lower end of the tether, slung on the pulley. They set up a remote position monitor and directional control on the plasma generator, to be controlled from White Sands when they were done with testing. They started up the tether moving, now functioning as a conveyor belt for the chunks of aluminum tank material being delivered from the space station down to the end of the tether. The chunks of aluminum were vaporized in the intense focused solar energy, ionized and escaped through the exit aperture as a high velocity stream of mass, in effect a rocket engine. Gimbaled to swivel back and forth somewhat randomly, the average thrust vector was controlled so as to be able to tow the huge space station, over a period of about a year, until it reached GEO, where it would be set to have the wheels rotate in the earth's equatorial plane. This had to be done so it would not be a hurtling big object below GEO, which eventually would collide with a structure that extended from the ground up to GEO. To make possible the original Space Elevator tether, Ownma had to first launch boosters to put the old long abandoned Freedom Space Station hulk up into GEO, to get it out of the way, too.

Saying goodbye, probably for the last time, to their little automatically tended agricultural facility in the wheel, the grain and cockroaches and quail, Improy and Catalie wore both space worksuits as they left the Embarcadero's airlock, re-entering their return winged spacecraft vehicle. They attached it to the descending side of the tether conveyor belt, joining the buckets of chunks of aluminum on the way down; however, they used their thrusters to guide them after release several meters above the solar powered rocket motor which was swung on the tether belt's lower pulley. They

stayed far clear of the blast of vaporized aluminum headed downward, soon were out of sight of the end of the tether, and began their second bounce and skip across the upper atmosphere, losing velocity and altitude while staying reasonably cool inside their vehicle, much as they had done about a year before.

But this time, their destination was not White Sands. It was Ecuador, as close to Cayambe as they could land safely. They dropped below the speed of sound high in the atmosphere, then continued their glide on their big wings across the equatorial Pacific Ocean, past the little floating island made of oil rigs where the former Space Elevator had been anchored to the earth's watery surface, and then across the coastline to circle the huge white-capped peak called Cayambe in Ecuador. they continued to lazily circle like an eagle looking for prey, spotting the section of straight dirt road which they could see had been blocked off at each end by Three Musketeers personnel for the landing. They came in low over the heads of some of the astonished natives, and touched down, skidding down the dirt road's ruts until finally stopping. They took a few minutes to calm their heart rates, unhooked their seat belts, popped open the nose hatch, and stepped out into the Ecuadorian high altitude sunshine.

Among the Three Muskateers staff which had gathered at the nose of the spacecraft to greet them was a young woman, who cautiously said "Catalie? Improy?" to them. Catalie affirmed it was indeed them, back safely on the ground again, glad to be so greeted. The young woman said "I am Idealiana, your daughter, and I am so thankful to see you again!" as she rushed over to give them a big hug.

Idealiana had learned from rumors at the Three Musketeers Corporation meetings that Improy and Catalie were going to come to Ecuador, since they could never come to TANFL City because of the ID implant problem. So Idealiana had volunteered to go to Ecuador aboard a freighter, to prepare for the expected arrival of her parents, and so here she was. She would soon have to leave on the freighter to return to her job in TANFL City, as most of them there would also. The crew could report only a few crewmen had died on the journey each trip, as had been common anyway before the Three Musketeers had come into existence. The presumed dead personnel would then never be able to return to anywhere there were TANFL ID pickups. Idealiana had a job to do in TANFL City, two of them, actually. One was her usual job serving the TANFL RichElite masters, then her second job at Three Musketeers Corporation, building computer terminals, and now to prepare to make components for the new space transportation structure to be built here at Cayambe peak. She now, at least, had found her parents again, so long lost. And Catalie and Improy had found their daughter again, last seen when she was only 8 years old, that was 11 years ago.

Chapter 26 Maybe can escalate instead of elevate

While Idealiana re-bonded with her parents, she also was learning about the new kind of transportation system they were going to build. It seemed incredible, a non-tether structure so big it would reach from ground up to GEO and go entirely around the planet in so doing. The Space Elevator she understood from when she was a child, living on the floating island for awhile while the former small Space Elevator was being built and anchored there. The tether had its weight supported by mass swinging around, like a ball on the end of a string being swing around, centrifugal force. The upward pull from a counterweight located on the tether out beyond GEO, as it was being swung around by the rotation of the planet itself, to balance the weight of the part of the tether that was between GEO and ground, along with the weight of its live loads, the payload-carrying vehicles moving up and down the tether. With a strong enough material per its mass, the tether could be in the form of a belt rolling around between two pulleys, one at each end, thus the belt also functions as a conveyor belt hauling material up and down between ground and its upper end or points between, such as GEO. Quite understandable.

But this other way of getting a structure from ground to GEO, although it too was supported by centrifugal force, was quite different. It did not use the centrifugal force generated by the planet swinging a weight around. It used the centrifugal force of a stream of mass circulating around the planet along a track, mass going faster than orbital velocity, so that its velocity in excess of orbital velocity expressed as outward centrifugal force against the track that constrained its path, and that outward force was "up"

relative to the planet's gravity that the mass stream was circulating around, and so supported the weight of the track's mass. Circulating mass traveling at twice the orbital velocity all along its circulating path, could balance a track and payload mass equal to its own mass.

It was a huge perimeter electric motor, she could understand that; as electric motors were a favorite subject of hers from when she was a child. The circulating mass stream was the motor's armature. The armature was given a push as it passed through the Earth terminal, then coasted around the loop, given another push each time it passed the Earth terminal's accelerator site. The armature also could electromagnetically drag other mass up with it, giving up a little of its kinetic energy in doing so, which would be replenished when it went through the ground site accelerator next time. That way, the payload-carrying spacecraft it was lifting, did not need to lift the mass of an energy source on its way up. And it was all-electric so eventually it could be powered entirely by solar-electric powerplants in GEO, which it would make possible to build.

So it was like the tether Space Elevator in what it could enable done. But the electric motor's armature had to be in discontinuous segments, as their distance between each other had to vary as they exchanged kinetic energy with potential energy as they rose and fell in the gravitational field of the planet. Keeping those armatures from bumping into each other required the motor to be a synchronous motor. The whole thing seemed a lot more complicated than the belt loop on pulleys of the anchored tether Space Elevator. Why do it that way? Both techniques for getting construction material from ground to GEO were all-electric and so ultimately could be powered from the Sun's energy as

received in GEO. Both could initially be made of small cross-section and then be used to scale itself up to whatever payload-carrying capacity was needed for the job at hand.

Both had the problem that the orbital space between ground and GEO had to be swept clean, eventually, to avoid collision with the structure; but with easy and cheap access to GEO, there would be little if any need for satellites in Low Earth Orbit anymore anyway. That was why the space access structures had not been built back when they could have been built in time to have provided the resources to have prevented the big mess civilization was not in, since it would have competed with existing aerospace which used LEO for its business, and business profit was what ruled. People were so irresponsibly shortsighted, she complained to herself, and now they were a dying civilization because of it. And killing a planetary ecosystem along with themselves. Was mankind too powerful for its own wisdom? Or could mankind pull the fat out of the fire? It looked like it was up to this project to see if it could be done, since the powerful business masters were sunk in their ego-driven luxury, partying until the show was over. They wouldn't have lived forever anyway, right? Yuck, what monkeys, she thought. Just very powerful cunning monkeys, addicted to playing games with each other, what ego-driven fun.

The tether material was the problem. It was reaching the limit of physical substances' molecular bonds strength for the mass of the atoms involved. Since it was operating near its limits of strength, it had little resiliency for transients. And in real systems, there inevitably would be transients. Since the earth-encircling structure technique did not have this molecular bond strength to mass ratio limit approached anywhere in its structure, it would be more reliable in

the long run, if its greater complexity was adequately coordinated. And the technology for the magnetic levitation synchronous track had yet to be proven, as it would only operate at high velocity in a hard vacuum.

She would focus on how to make those little armature segments the motor needed, that sounded interesting. And zillions of them would need to be made, a manufacturing task, something that was her speciality.

Chapter 27 Ecuadoreans pitch in and make it their project

The freighter, normally empty when it left the Port of TANFL to go get a boatload of bananas for the RichElite, this time had brought a lot of equipment belonging to Emplos and The Three Musketeers, and five of the original landed ID-less former prisoners had come along too as unregistered passengers, since their work was done in initial setup of the Emplos ways in the Employee sector of TANFL City. There were also three of the ship's crew that would be listed as missing and presumed dead during the voyage; a typical trip would lose that many of the crew anyway, back before the Emplos crew showed the Employees, and ship's crew, better lifestyles.

Idealiana had to be back on board the freighter by the time it was ready to leave with its freshly loaded cargo of bananas, so she said goodbye to her parents and the people who had made the one-way journey here with her aboard the freighter, and headed for the boat. She was looking forward to collecting more knowledge from the Emplos main group over at White Sands, during the brief moments the space station was above, they all could exchange chats and knowledge bases while at sea, but did not dare to do that when near TANFL City for fear the Owner-Manager masters might intercept the messages.

Catalie's focus was now on how to get the local Ecuadoreans to become involved in the new project. The country had not escaped the general economic and environmental failures that the higher latitudes had experienced, and had little government remaining and few people; but some natives were sticking it out to the end up here in their homes. It was hoped that they

could become interested in the Emplos ways, and join in. The nearby town of Cayambe still had over a thousand people struggling to live there, all of which would be very welcome members of the immense enterprise being started here, with such high hopes for helping mankind and the world ecosystem.

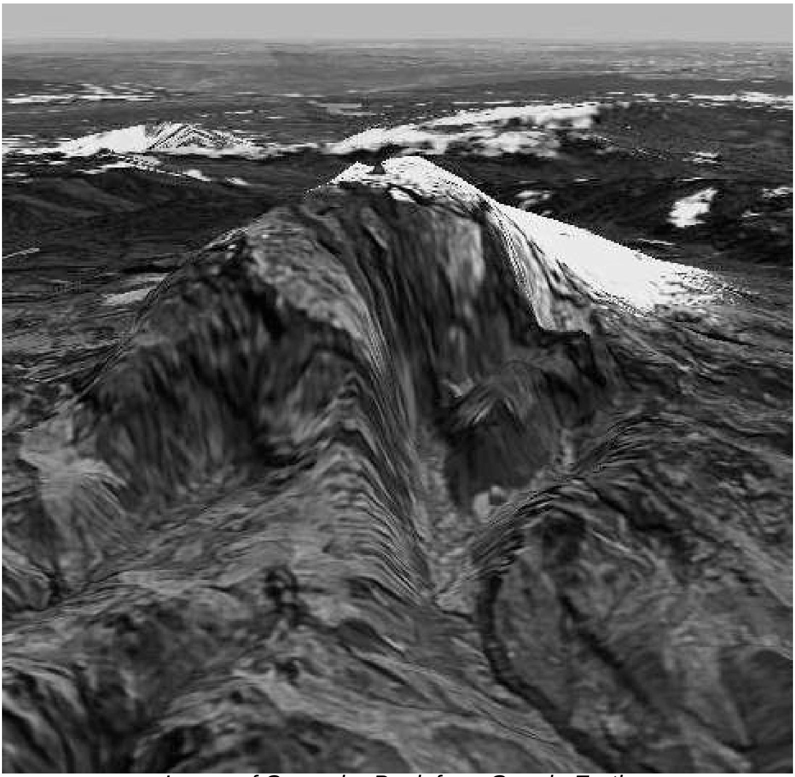


Image of Cayambe Peak from Google Earth

They negotiated ownership rights to part of the Cayambe mountain peak area, from the owners of the land, best they could determine in the circumstances. The village of the same name as the peak claimed ownership of the mountain area including the peak. The villagers acted as if nobody who was sane would want

the peak, however; but granted rights to part of it anyway, as requested. Improy's crew had determined the lowest part of the peak that was at least 200 meters higher than any other area in Ecuador or Brazil along the equator, centered that location on the western slope in alignment with the peak in an east-west direction, and started digging eastward into the mountain. There was a deep channel that led from the town of Cayambe right up to the site, which was as an extension of that valley. It was quite a hike up there from the town, but it was fairly direct. Having marked the location of the western end of the tunnel to be, they returned to town, and again negotiated for some land property, next to the place where the spacecraft had glided to a skidding stop; it was hard to move and was needed to be their initial home and office. They built a greenhouse for their usual mini-farm, populated by the grains and animals descended from those that had been in the space station wheel. They bartered again for some nearby dwellings, some of which were then set up to be computer terminal sites, and all the locations were linked by tight beam, forming their usual local network configuration. The moved off a few hundred meters and set up a targeting transmitter and a small rectenna array, so that when the space station was above there area and not beaming to White Sands site, it would beam them microwave energy derived from the Sun. They used the same storage techniques developed for use at White Sands, and so had a small amount of continuous electrical energy to operate their computers; and occasionally had a large input during which they could also run power tools directly.

Among the villagers were some engineers and other well educated people who had retreated up here as their normal world disintegrated in the dying world economy and world ecosystem. Catalie invited them to examine their instant education workstation setups, and

invited them to participate by adding their knowledge to the system while having access to all knowledge already in the system, and delivered such that it was just was what was needed to do whatever job they specified at the terminal. The educated folk had their old interest in learning rekindled by the terminals functioning, and soon were gathering around 24 hours a day for their turn at a terminal. As now a familiar pattern, the first workstations were focused mostly on preparing to build more such workstations, identifying the raw materials and instructions for building up from there, each step presented after the preceding one was declared achieved. They had to partially cannibalize the spacecraft for some of the materials, as equivalents were not to be found quickly locally. The rectenna was enlarged to utilize a larger part of the microwave beam delivered occasionally, as the requirement for electrical energy at the Cayambe site increased.

They used the native's techniques as much as possible for providing clothing and shelter, and some metals, so as to put their high-tech materials to use in making more education-workstations. Some of the natives of the village learned of what was going on and wanted to be shown; and soon some of them were inputting their language translation and local lore into the expanding database. The workstations had text onscreen, graphics on screen, audio, and tactile-kinesthetic simulator input-output transducers, so a wide variety of kinds of knowledge could be input, including weaving of decorative baskets and preparing native cuisine. Since the school system had long since failed, the villagers appealed to let their children use the terminals to become educated. The agreement was always to trade knowledge for knowledge, so the network began to accumulate knowledge about how to play children games and find local fauna and flora. As the Ecuadoreans began to comprehend the whole

system, some chased down the energy source to operate the computer network and terminals, and found it ended at the rectenna. They asked the terminals about the rectenna and discovered the whole larger picture of an abandoned dual wheel space station was orbiting the planet up there and when convenient it would beam some electrical energy down to the rectenna for their use. It also had the history of the space station, and the knowledge that it was slowly being towed to ever higher orbits by a solar powered ion thruster. It all was a bit hard to believe, but the electrical power that would suddenly appear at the rectenna site was an indication that it likely was true. So then the question came up, why had they come here, to this inhospitable location? Were they just still practicing at coping with inhospitable locations, or did they have something else in mind?

So then they were ready to be told that a horizontal tunnel needed to be made through the mountain peak near there, running in an east-west direction. And into that tunnel would be built the ground terminal of an energy supported structure that would encircle the whole planet, reaching up to GEO above the opposite side of the planet, from where little could be seen except ocean and little bits of land on the edges of the round disk. That place would be the construction site for the immense machines that perhaps could save their civilization and make it possible to take mankind's load enough off of the planetary ecosystem as to enable its resurrection as much as possible, based on whatever species that had been saved at that time. It all required a level of cooperation among all peoples, however. They did not know how to deal with the TANFL Corporations who had only interest in accumulating wealth, not in saving the system which provided wealth. All they could hope to do is provide the technology, the means, the

transportation system and the machines up there in GEO to provide all the electrical energy people could possibly want, and without having to damage the ecosystem while doing so. Then they said they hoped all of the people of the village would join in on this effort with them, to whatever extent each was willing and able to participate. Because at this point it was mostly a volunteer activity.

The people of the village exhibited an amazing enthusiasm for the project, and in their spare time and when not on the education-workstations, were busy making a pathway up the valley to the site of the tunnel entrance marked location, and were building a dwelling there out of local materials.

They made the dwelling an outpost of the village; and powered by a hand crank generator, installed one of the newly built education workstations there, linked with the others by a tight RF beam, as the others were, but of a bit higher power. Some people began staying there for days at a time, hiking up there with food and water, then using the education-workstation in between using pick and shovel to begin the tunnel through the mountain. They had caught the enthusiasm of the Emplos Corporation, taking on a project even though it seemed nearly impossible to do; if the purpose was valuable enough, it was worth the struggle, they had learned, and so they were whacking away at the rock of the mountain chip by chip, preparing the way for a pathway to Geostationary Earth Orbit, place to build that which civilization needed to survive and even eventually prosper on a world again blooming with life.

One of the village refugee engineers had been a mining engineer, and knew of some mining supplies which had been long abandoned, but possibly useful. So a group made the journey to there on foot, returning

with the supplies, and soon the progress on the tunnel was being driven quite rapidly. More trips were made to the old mining site, bringing back the old tram that had been set up there, cables and all, hauled by some burros. Once it had been set up, the weight of tunnel debris in the downward buckets lifted people and goods up the up-side of the tram, no motor required.

Meanwhile the banana freighters had been bringing down material from the Three Musketeers Corporation, who had access to the abandoned remains of the wider city around their outskirts for all sorts of materials as starting points for the building of the space transportation structure. It had been stockpiling at the Ecuadorean dock facilities, and eventually word got to Improy of the stockpile's existence, a crew from the village took on the task of getting it to Cayambe.

It also made it a lot easier to build the education-workstations, so much work was done to make them and install them in every home in the village that wanted one, which was most of the dwellings. These were powered by hand cranked generators, so they were operated only a little bit of each day, but it was a high point in each household where that was happening. Kids could do their schoolwork on the education-workstations, one would crank on the generator while another would use the terminal; then they would switch places.

Part of the charm of the education-workstations was that its data presentation was in a form that was cheerful and easygoing, as well as concise and integrated to the context of the work being done at the station at that instant. And the user had choices of preferred formats, including some were anthropomorphic, while others were more abstract

without the personification of the significant items. This made it blend in with various ways peoples' brains were wired.

Word about this traveled to neighboring villages, and when weather was permitting, people were showing up at the villager's homes, asking to see the thing. Many of those people wanted the terminals too. The Cayembe villagers by then were fully capable of building the terminals themselves, and easily looked up how to run a relay beam across the rugged terrain to other villages, and the system was expanding. They were bartering for supplies, materials and labor, as no currency was functional there anymore. In those terms of wealth, the village was becoming wealthy, materials which they hoped would help build the new transportation system as well as make their own more immediate existence better.

The dream of the new space transportation was spreading along with the education-workstations, too. And with it hope for the future. Catalie put out onto the network a request for people to save breeding populations of any species they could preserve, somehow keep them going for another decade or two, then things might have turned around enough to release them back into the environment in an orchestrated way. But they had to be alive still at that time; extinct would not work. Diversity was needed to give a re-seeded world its best chance to recover.

Hundreds of volunteers showed up each day to help do something. Most of them brought picks and shovels for digging in the tunnel; but since only a few could do tunneling at any given time, the volunteers chose to widen the foot trail up the channel, making it wide enough for two way traffic of wheeled motorized vehicles. Optimism was a characteristic of those who

had been using the education-workstations with its database for whatever they needed doing, and were seeing it as a way out of the big mess things were in.

But they were ignoring the fact that at the present time, they were forgotten, left to die in the middle of nowhere, by those who were masters of collecting the wealth of others. Sooner or later, it was likely that the Mega-Corporation Owner-Manager masters would show up and rip it all off, having no regard for what it was needed to do, obsessed with accumulating their own wealth without end.

Life does proceed on when possible, so they continued to dig tunnel through the mountain, and improve the road to the tunnel, having gotten the dream of what it was for. Meanwhile they were continually getting a combination of education and skill simulation practice on whatever was interesting to each individual, on the education-workstations that they were now themselves also building, mere months from their peasant life in the high altitude refuge village state of life and mind.

The miners worked day and night, disregarding the stormy weather that sometimes made their trip to and from the construction site quite uncomfortable; yet they came and worked. And one day they broke through to the other side of the mountain, and looked out across the rugged canyons below them. A milestone had been achieved. Through this tunnel would pass a structure which would reach GEO above the opposite side of the planet, as it looped around to the other side of this tunnel. It would happen right here, in their home.

Word spread far across Ecuador and Brazil, about the education workstations and the transportation

structure that was being attempted to be built. Donated materials began to come in, hauled on the remaining trucks that were powered by pulverized coal. Some of them carried sections of aircraft from an abandoned airport. Improy and Catalie used some of this material and the remains of the glider spacecraft that had brought them here, and built a new kind of spacecraft, one that had the same cast foamed aluminum wings, nose cone and underbelly, but was only a two seater and was equipped with a rocket engine. A former large solid fueled missile was found and brought over, its warhead removed, and set up to be a launch booster for the manned part of the vehicle. The rocket also carried a huge bobbin, wound with a tiny fiber that had rigid hydrogen-filled pockets spaced along it, and small magnets also periodically embedded along the fiber, and was overall lighter than air, designed to float at 15 kilometers altitude.

One end of the fiber was anchored inside the tunnel, then the fiber was strung down the mountain and out to where the launch vehicle sat atop its booster rocket; the fiber was kept taught so it was at a steep angle, well away from the exhaust plume that would come from the vehicle during launch. As soon as the vehicle was fueled and ready, Improy and Catalie climbed up the ladder and into their seats in the cockpit, again wearing their space worksuits. The solid fueled booster fired first, kicking the main vehicle vertically until it ran out of fuel, then dropped away; the bobbin's fiber had been madly paying out all the time. Improy ignited their own engines and kept heading up, a little toward the east, soon out over Brazil, and the bobbin was just a blur of motion as layer after layer was pulled off, as the fiber was payed out behind them. They tilted more towards the horizontal, then their engines ran out of fuel. Then they began the now familiar bounce and skip across the upper atmosphere, coasting around the

planet, leaving the trail of fiber behind them. Out across the Atlantic Ocean they went, bounced and across Africa, bounced and across the Pacific Ocean, losing speed and altitude. As they approached the Ecuadorean west coast, Improy swung the glider to yaw to the side and the vehicle shuddered as it lost velocity and dropped rapidly toward Cayambe mountain. Beginning to wing around past the peak, he jettisoned the bobbin with the remainder of the fiber on it; then he circled until losing enough speed and altitude to once again come into a skidding landing on the road where they had landed before, that time back from a visit to the Space Station.

Crews had already headed off to where the bobbin had landed, and eventually brought it back to the west end of the tunnel. Inside the tunnel they joined the two ends of the floating fiber, now a strand that encircled the whole world, somewhat raggedly in shape, winds blowing here and there. They had no time to waste, so they placed the now continuous loop into the linear electric motor stator they had built through the tunnel, and powered by a coal-burning electric generator, the magnets along the fiber where alternately pulled and pushed by hall-effect-sensing driven magnetic pulses. Not too fast so as to bunch up, nor to over tension the part of the fiber off toward the west. the accelerated part was like a pulse of energy that traveled around the fiber, all the way around the planet, and when it had reached Ecuador from the other direction, the electric motor was speeded up again. And so the fiber began rotating around the planet, adding a centrifugal force component to its lighter-than-air urge to altitude.

Eventually the fiber was traveling the fastest it could, with the electric motor's power being expended by air friction losses; it all reaching a balance.

Chapter 28 Fibers circulating around the planet faster go further outward

They hooked another fiber to ride along the first fiber, a barbed point occasionally along the new fiber, which also had magnet inclusions distributed along it, the first fiber carried it with itself around the planet, back into the tunnel, and snapped onto itself to form another continuous loop. The second fiber had its own similar linear electric motor armature down through the tunnel, through which the non-floating fiber was diverted, then was accelerated faster than the floating fiber; and as the faster portion traveled around the world the barbs unhooked from the floating fiber, and the thin fiber was being supported by its outward centrifugal force. When it was completely unhooked, the floating fiber was cut and reeled back in as it finished its final circuit around the planet and back into the tunnel.

This finer fiber was then speeded up until the stator could push it no faster, overcoming air drag losses. But now this fiber was centrifugally reaching quite high, stretched into the upper atmosphere for half of its path around the planet, so the drag was much less there.

A similar fiber on a new bobbin was brought up to the tunnel, and driven by its own synchronous linear motor stator, laced to the loop already speeding through the tunnel, being carried by the first loop, which was dragged down somewhat for awhile in its higher areas, but as soon as the second loop had completed the circuit of the planet, it had been restored to the original shape, above the atmosphere on the other side of the planet.

The continuous form of armature could not be used for peak altitudes of about 170 km, since the constant velocity had to be about orbital velocity at its highest altitude, and the stress on the fiber's tensile strength had to take up the slack below that altitude. To go much higher, they would have to switch to discontinuous armature segments.

They had to proceed by small steps, learning with everything they did, and that being immediately spread to the furthest corners of the education-workstation network for any who cared to access it. Even a great many of the native Ecuadoreans were following the progress every step. They also had to wait for the dual wheel space station, being leisurely but surely towed by the solar powered ionized aluminum reaction engine on the end of the tether, to finally reach GEO, so as to be out of the way; and hopefully become the initial terminal when the new transportation structure reached GEO.

They were getting useful data out of the current continuous armature structure, however. And the reality of now having a structure that reached entirely around the planet, and extended above the atmosphere in part of the path, had its psychological impact. Something like when the first people flew in the earliest heavier than air aircraft. The moment when analysis and belief that something ought to work, is actually seen and experienced working firsthand.

The easily duplicated microminiature component manufacturing facilities that made the education-workstations, combined with the rapidly expanding competency and enthusiasm of the users of those workstations, began producing test prototypes of sections of laterally coupled magnetic levitation track tubing pairs, along with the microminiature sliding

armature segments. When the continuous armature structure had been scaled up sufficiently to carry the passive load of one of these experimental tubing pairs, it was lashed to the speeding loop as it passed through the tunnel, and so it was strung around the planet and joined in the tunnel. It went through its own accelerator as each of the other fiber sections were doing, but this one was different. Once the dual tube track structure was a continuous loop, the synchronous linear motor serving the dual tube, began to pulse electromagnetic acceleration energy to the previously passive armature segments inside the tubes, but one set of armatures went backward to the motion of the supporting fiber motion, while the other set of armature segments in the other tube went in the same direction as the fiber moved. Flapper valves were on the tubing, allowing air to leave the tube but not to enter, and so when the tubing was high above the atmosphere above the far side of the planet, the air inside the tubing was vented to the vacuum of space, gradually creating a good vacuum inside the tubing. This allowed the armature velocity to be unimpeded by gas molecules inside the tubing, and so they were completely floating on their magnetic levitation microtracks. And being speeded up each time they came around through the accelerator in the tunnel, building up speed. In that way, they were able to establish values for the characteristic parameters of the system, including limits that prevented collisions between armature segments and collisions with the track or tubing walls, as they were buffeted laterally by gusts of wind on the tubing during their journey around the planet when in the atmospheric area.

The real-world values for the parameters thus established, they slowed the dual tube armatures to a stop, and peeled the whole dual tubing off the continuous armature supportive fiber.

Back to the drawing board, for both the track, tubing, and armature segments. And for the tunnel's accelerator pair. Manufacturing the newly optimized value components, they again had the continuous armature speeding fiber strung around the planet, and its dual streams of armature segments in motion, and pumped down by the valves when above the atmosphere. This configuration held together until reaching to twice the orbital velocity all along the path. The average mass of the armature mass stream was the same as the mass of the tubing it passed through. Then the forward-moving armature segments were triggered to deliver a small portion of their momentum to the tubing through electrodynamic tubing through which it passed, speeding it a bit faster than the supporting fiber loop was going, freeing it of the distributed barbs, unzipping it free of the continuous armature fiber; then the velocities of the pair of armature mass stream was adjusted and braked such that the tubing became slowed, gradually reaching a state of motionlessness, while the armature mass streams inside it were going far above orbital velocity, their outward resultant centrifugal force balancing the weight of the tubing inside which it flowed. The targeted configuration had been achieved. The tubing was anchored to the inside of the tunnel, and a new characterization was made, refining the parameters of components for this motionless tubing track configuration.

Several more similar tubing pairs were put in place by the continuous armature fiber speeding structure, and each of these then were internally sped up to support the weight of the tubing, detached from the fiber, slowed to halt the motion of the tubing, and then it was lashed to the first tubing pair. In this way the armature segment form of structure was scaled up until it could support the weight of a passive pair of tubings

that were caterpillared along the multiple tube structure, being dragged along by the dynamic braking against the upward-bound set of armature segments excess velocity. Eventually reaching around the planet, that new pair soon joined the bundle, adding to its scale up.

The dual wheel space station had almost reached GEO, so it was time to go for real. They started one of the tubing pairs moving forward, unhooking it from the rest of the bundle, and when it was an independent loop around the planet, its linear stator motor was modified to operate in a pumped down chamber inside the tunnel, where each side of the tubing was opened, its armature segments coasting in the vacuum briefly, re-entering the tubing on the other side of the gap and continuing on as before. In this gap they were able to able to spool a ribbon addition to the exiting tubing, the ribbon folding around and welded to form tubing after the armature segments had inserted in it; and additional armature segments were added in the same process. This was done in both directions of the motor accelerators exits, and thus the overall length of the structure was increasing. As the length of the loop increased, its armatures were speeded up correspondingly, so as to lift the structure ever higher in its planet-encircling loop. Up it went, bit by bit, until it reached GEO above the far side of the planet.

They similarly expanded another of the low altitude loop tubing pairs, to join the first one. And when they had the whole bundle extending between ground and GEO, they used the whole bundle to support the weight of an added pair of tubings. And when that bundle of tubings was able to support a dual tube of larger diameter and armature segments, the scaling up began to increase rapidly.

When the girth of the bundle had reached 30 square centimeters, they paused the scaling up to attach a tubing pair that carried an additional pair of magnetic levitation tracks on its outside. Then it was looped all the way around the planet, up past GEO and down around to the other entrance of the mountain tunnel, They placed a small test vehicle to slide on the tracks while being dragged along by the upward-moving armature segments inside the tubing. Carrying a small video camera and a couple of transducers, it sent its camera and sensor data down the tracks to be picked up in the tunnel.

Watching the video as it crept up and around the planet, it looked down on the planet from GEO briefly, then continued on around and down the other side of the structure, eventually coming in the other end of the Cayambe peak tunnel. The first trip had been made from ground to GEO, carried by that type of structure.

Chapter 29 Limping along space access structure construction

The construction and use of the space access structure was energy starved. As there were no electric power lines existing servicing Cayambe, the Ecuadoreans pitched in and got a powdered-coal fueled electric power plant brought in to the construction site, and while that fuel supply lasted, they could speed up the scaling up construction of the structure. At some point they would need to shift to using energy resources for lifting materials up to GEO to build a Satellite Solar Electric Power plant, with which to power the transportation structure thereafter.

The supplies available to fuel the coal-powered electric power plant were rationed and getting less each week. So when the diameter of the KESTS structure to GEO reached 36 cm, they called a temporary halt to the scaling up process. At this point the mass of the structure was 4E10kg, and the structure was capable of receiving 600 megawatts per hour while lifting 20 million kg of mass to GEO each hour, so it was extremely underused, being only powered by the small powerplant on site. And that powerplant was running out of allowed fuel ration, too. They had to get to building the solar electric powerplant built in GEO as soon as possible.

They had instructed the old dual wheel space station to be towed to where it could continually beam microwave energy to rectennas to either the White Sands location, or to the Cayambe location. They arranged to time share the energy beamed down from its solar power source, a kind of SSPS, but welcome addition to the petrochemical powerplant. They used the energy primarily to lift the construction materials for

a SSPS capable of delivering 600 MW of solar-sourced energy continuously to the earth surface, If they could achieve that before their earth sourced energy supplies ran out, they could at least run this KESTS at full capacity, building more solar electric powerplants, and start negotiating with countries for delivered electric power, and start having an income. From then on, things would be easier.

As it was, the combined energy input from the coal-fired electric power and their average share of the space station's beamed energy was only half a megawatt, with which they could only deliver 15,000 kg to GEO each hour. They chose to build the main structure of the powerplant out of glass cast in a hard vacuum, which had enormous strength to mass ratio, far greater than the finest steel or aluminum, so long as it could be kept free of the atmosphere's molecules wiggling into glass surface microcracks, wedging into the glass until it was as fragile as it is normally on the earth's surface. They chose to melt the glass down at the KESTS ground terminal, and haul it up to the GEO construction site while still in the melted state, for feeding the extrusion facilities making the SSPS.

The structure had severe limits to the amount of concentrated load it could carry, however. It was very efficient at lifting a fairly continuous series of payloads of about equal mass; but the limits to concentrated mass load meant that they could not just haul up a solar powerplant ready-made. So Improy and Catalie went up in their little two-person spacecraft again, this time being lifted up by the KESTS, about its limit of a concentrated mass load. They only had a brief time they could work in GEO, being without passive radiation protection, and the injected DNA repair substance formula had long since been lost. So they used their space worksuits to assemble the solar-

electric power panels into the glass main structure, and connected it to the microwave beam generator.

Looking down from the construction site, in GEO above the opposite side of the planet from the Ecuadorean mountain tunnel site, the world looked mostly watery. They were out of touch with ground facilities, and they dare not try to link into any internet signals that might reach up here. They then set up the silicon solar cell automated fabrication plant, which liked to be in zero g and hard vacuum, solar powered. Then they hurried back down the KESTS back to Cayambe peak tunnel, for a well earned vacation.

Chapter 30 Houston returns to life

When the signal was received from the SPS construction site, indicating completion of the local fabrication of the require solar cells for the larger solar power array, Improy and Catalie again made the lift up the partially built KESTS structure, from the Cayambe tunnel in Ecuador, around the Earth upward to GEO above the opposite side of the Earth, where the Solar Power Station was being built, mostly automatically, but occasionally needed on-site human versatility for some specific tasks.

Assembling their space worksuits around themselves, they left their winged spacecraft and moved the huge batch of solar cells into the assembly hopper of the solar panels, for automated placement and electrical connection and testing of each one as installed. The microwave generator and directing array was already in place, all it needed was electrical energy, and lots of it. As the solar cells were hooked into the solar panels by the robotic assembler, the electrical energy of each one would be added to the energy available to the microwave generator and its control circuitry. They setup the manufacturing and transportation monitor equipment, which would continually evaluate the performance of all the systems up here in GEO and also of the KESTS electrodynamic transportation structure itself. They put in known transients into each system and watched for the monitor's evaluation that resulted.

The systems were growing up here not just in size and complexity, but also in their multiplicity of functions, often interrelated. The Emplos Corporation and the Three Musketeers Corporation had very limited resources, which limited what they could do even with

their interlinked education-workstations which was still proving extremely powerful in raising the competency of people and their enjoyment of being part of the larger process. Catalie and Improy had a way they hoped would bring significant new resources to the system, so as their endurance time ran out up here unshielded in GEO, they returned to their captive winged spacecraft, rode the KESTS structure down to the fringes of the atmosphere, and set their winged spacecraft free.

They had to drop awhile in order to build up speed, then their large foamed aluminum glider wings rode the relative wind, and they once again did the bounce around the planet, losing altitude and speed slowly enough as to not get uncomfortably hot along the way. But this time their landing destination was neither Cayanbe nor White Sands; they were going to the long-abandoned remains of the space command center in the ghost town of Houston. They landed at the runway of the abandoned airport, skidding to their usual halt. They had to leave their space worksuits there in their glider spacecraft, too bulky for their long hike to the space command center remains.

Historical data was sketchy, as to what happened to the once proud Houston Space Command of NASA. When the mega-corporations arranged to fix the elections, and then have the country turned into a gigantic business instead of a country of people, everything was privatized, including NASA facilities. It was given by the new government to a giant toy manufacturer, the mega-corporations seeing no quick profit in any space ventures, so they got rid of NASA and gave its facilities away. The toy manufacturer saw the Houston space command center, with all its computer monitors, as being most nearly an arcade. So they sent a team in to make the consoles to run computer games for teenagers. The government-super-

corporation gave each of its subsidiaries 3 months to streamline their takeover operation, and another 3 months to show a profit. By the end of the second quarter, the Houston space command arcade was not showing a profit, so it was abandoned, its doors closed, and walked away from.

The understandably frustrated kids had gave up trying to play their favorite computer games on the imperfectly modified consoles of the former space command center, and they had gotten in a fight with each other, throwing handy objects, some of which had hit the consoles. The place was then abandoned, decades ago. The world had been a state of collapse from even before that, little of high technological sophistication got built afterward.

So Improy and Catalie considered the remains of the former space command a gold mine of parts they could use. The remote eyes and ears of the worldwide communications system was no longer working, of course. But they did have some big dishes locally, and they manually set one up to aim at a relay link that they had positioned on the KESTS where line of sight existed both to the GEO assembly station above the equatorial ocean, and also to Houston, Cayambe, and to White Sands. Improy set up one of the education-workstations which they had brought along, and connected it through the KESTS repeater transceiver, and was immediately locked into both the home base at White Sands and the GEO assembly site. Indulging in only the briefest welcoming chats with the people at White Sands, Catalie went through the checklist of monitor functions and data output from the GEO site. Based on that data, she made some changes in the timing and sequence of the manufacturing process, and left the manufacturing assembly automation to run some more.

She then turned her attention to the monitoring of the KESTS transportation structure. There were two particular concerns she had right now, involving the structure's ability to servo-position adequately in response to transients. One kind of possible transient was that of the seismic wave of an earthquake; one such had been recorded long ago on the opposite side of Cayambe peak from the village of Cayambe, so it was possible to happen again.

The other transient type was from winds causing shifting lateral loads on the KESTS structure in the atmosphere. Such lateral loads were compensated for by unbalancing the distribution of armature segment velocities around the perimeter of the cross-section of the KESTS, the lateral stresses produced intended to balance the stresses produced by wind loads. But the energy distribution amount the armature segments was set when they left the Cayanmbe tunnel accelerator site, and little was possible after that to change their pattern of sideway push against the structure from within it. Sudden and sustained wind shifts that had not been predicted adequately, was the big worry and so was being monitored and relayed to the ground for human evaluation, getting data for the computers that would do it automatically thereafter, mimicking the human's responses. The KESTS structure was essentially horizontal out across Brazil in one direction and the Pacific Ocean in the other, for a long way before the curvature of the earth surface was dropping away out from under the KESTS lesser curvature. If the winds broadsided the structure across a large distance, it could put quite a lateral wind load on the KESTS structure. And if the winds shifted to rapidly, it could cause possibly insufficiently unbalanced forces within the KESTS internal trackways. They were doing reality testing a bit more than she liked. So far, things seemed to be well within the limits of compensation.

Meanwhile, Improy was taking stock of the abandoned equipment that might still be useful. The electronics technology utilized in the consoles had become obsoleted with advances in technology for awhile; but then with the implosion of civilization, its technology became irreproducible. Some of the circuit boards' population of integrated circuits would be best used as models, when put into the new manufacturing system used for making the education-workstations. Their imprint could be copied into the knowledge base, perhaps new things would result.

Whatever, Improy and Catalie were stranded here in Houston, no way to fly their spacecraft out any more.

Next is a short story written just for the experience of translating one of my own life adventures into a sci fi fantasy story adventure, “Crisis On First KESTS,” which on a timeline would follow “Building Up.”

Crisis on First KESTS

- A Science Fiction short story by Jim Cline -

The sound of heavy winds and lashing rain battering on the windows and wall of the prefab structure high in the Andes Mountains in Ecuador woke Techerson a little; then snuggled closer to his wife, thankful for this warm cozy place, sleepily. Then the sheet metal walls rumbled with a particularly hard gust against it, and suddenly the comm link sounded urgently for attention. There has been a system failure, his boss said, control central in Houston reported the system's safeties had shut down all but operations necessary for its own survival. It had been lifting a series of cargo spacecraft carrying hot-weld components in an ongoing construction task; the spacecraft were stopped, locked in place hanging on the outside of the KESTS, far below GEO, and the buffer supply of hot-melt components being used in assembly would run out in 3 hours, and that system would have to shut down too if no resupply by then, and it would take weeks to get it going again if that happened. The project did not have weeks to spare; they had to get the first Satellite Solar Power Station online in GEO before the last of the quota of petrochemical fuel was alloted for the project had been fully consumed. That SSPS could then power the KESTS, independently of earthsurface failing energy supplies, and could be the start of recovery of the civilization built on easy cheap energy, now starving to death for lack of adequate energy.

Kissing his wife goodby quickly, he put on his maintenance environmental jumpsuit, went out the double door lock into the storm. It was so beautiful here normally when he went outside to go to work, but now

barely recognizable in the darkness and rain being hurled against his environmental suit, splotches of wet splaying on his faceplate erratically. His hand guided by the cable set in posts along the rough-hewn pathway along the cliff face, soon he got to the edge of the tunnel aperture in the side of the mountain, and looked at the horizontal tube extending out from the tunnel horizontally as far as one could see, even in daylight. The KESTS tube was already over a meter in diameter, yet much smaller than fully operational size; its scaling-up construction temporarily halted to prematurely start building a solar electric power station in GEO with material lifted by this first KESTS to GEO, due to political turmoil as nations made the final power grabs for the remaining fuel oil reserves. If it did not manage to get its own solar energy derived electric power going before the oil for energy allocation ran out, the project would be shut down, and mankind would be forever chained by gravity to the earth's surface, not even fuel for one manned rocket launch thereafter.

But something had gone wrong; the KESTS's fault monitor system alarm had been sent, the system had shut down its transportation of cargo spacecraft. The wind boomed resonantly into the tunnel's cavern face, as if challenging the right of this intruder KESTS to take root here in its domain. He turned the tunnel service lights on, and stepped into the tunnel tram, went to the maintenance control room. Glancing wistfully at the unfinished holosystem control station, he went over to the tall dark racks of electronic control racks, built of old technology scrounged for the task, the economy already shutting down on development funds. Its glowing lights and numeric displays by the thousands, the failure probably causing alarm indications far down the line from where it actually was. Intently looking at the computer display screen graphic of the overall system, it showed a small circle symbolizing the earth's

equator, which was encircled by a large circle symbolizing Geostationary Earth Orbit, about seven earth radii out from center of the earth, and the KESTS structure which was symbolized by an ellipse around the earth, touching the equator at one point and touching GEO above the opposite side of the earth. It showed a red splotch on the ellipse that symbolized the KESTS transportation structure, very close to where it touched ground. This was confirmed by the earliest indication on the alarm lights pointing to a section of the KESTS about 35 kilometers out from the tunnel, still deep in the atmosphere, storm still battering the structure even there. A layer of the KESTS tubes was ruptured, probably by the lateral servo control exceeding its capacity in compensating for lateral wind forces with the rain as hurled battering mass, and the high velocity armature segments had hit the wall and blown out the tubing.

Techerson looked at the pattern of failure lights, guessed the deepest mass stream tube had blown and took out the 14 of them above it to the outside edge of the KESTS, as built so far of many layers of armature mass stream tubes, scaling up bootstrap toward full capacity size. He checked to see that the safeties had indeed automatically switched the incoming armatures of the 15 tubes as they were incoming back from their run to GEO, so the only armatures lost were the 35 miles of them that had been past the accelerator in the tunnel. It would take about 5 more hours to finish the dump of the armature segments from the damaged tubes; the overall fate would be decided long before that. He climbed into the emergency maintenance gondola, its battery and traction motor would last for several hundred miles and he preferred not to start up the KESTS vehicle lift coupling yet. The gondola moved down through the long Andean tunnel, then exited through the darkness into the storm’s fury, vibrating the

gondola as it swept out over the Pacific Ocean along the equator. He would rather have waited until daylight and storm abatement, but neither sun nor storm would change much in the few hours available to get the KESTS going again.

The maintenance spotlights of the gondola glared upon the patch of torn up tubing at 2 o'clock on the KESTS girth. Sealing the hatchway to the KESTS surface was easy even in the storm, a hatchway seal that would work in the hard vacuum of space far above the planet. Cutting into the tubes identified by the monitor system, he pulled the outer ones up, followed back to where the tubing was still undamaged, made clean cuts, and spliced in new sections of tubing; using the splicer he aligned the maglev trackways to tolerances invisible to the eye. First the deepest tubes, sealed down into precise alignment within the KESTS structure, then one by one the ones outside until the outer layer was patched. He climbed back out of the hatchway into the gondola and activated the hatchway release, the electrically switched chemical bonding adhesive suddenly switched to their slippery mode, and pulled back into the gondola. Reversing his path, the gondola cruised back along the KESTS toward the mountain tunnel; he was dimly aware of the unseen dark ocean a couple of miles below in the stormy darkness.

An hour and a half had passed, about that much time yet to go at max. As the gondola slid along the KESTS into the mountain tunnel again and docked to the maintenance control room, Techerson stepped out toward the bank of antiquated equipment make-do control panels, equipment which had done their automatic job well so far. He selected one of the outer tubes, directed it to stop the dump of sliding armature segments, and instead to allow them to continue on through the tunnel toward the area he had patched. At

30 Km/s it was but one breath's time until the repair site was passed by the high velocity armature mass stream segments; he breathed a sigh of relief when no new alarm light lit. He then picked the innermost repaired tube, it too passed successfully. One by one the remaining tubes were re-activated. He began the rev up sequence for the full dozen of armature maintenance storage rings adjacent to the tunnel, to bring replacement armature segments up to speed for injection into the KESTS mass stream when the gaps began to appear, which would start soon as they finished their full loop around the Earth, so the gap in the armature segments would be re-filled when that part of the mass stream had gone around the loop to GEO and entered the tunnel.

He carefully looked over the pattern of LED indicators and numeric displays, compared values with those before the break happened, they seemed within acceptable ranges, well below the failure point loads. Moving over to the spacecraft lift local control panel, he got on the comm and told his boss it was time to re-start the lift, turn on the upward drag inductive lift for the spacecraft which was highest first, go slow and minimum spacecraft lift energy consumed while the KESTS's internal stored energy was needed to cope with the severe lateral wind loads of the rainstorm. Too much energy was being consumed to compensate for the high lateral storm loads on the KESTS, so just get the lead cargo up to GEO in time before the 3 hour storage glass melt hopper was emptied, then limp subsequent cargo spacecraft upward so they would arrive just in time, until the storm had abated, and full transportation capacity could be restored. Before leaving the facility, he entered the log data which had real values now, of how much load the KESTS could take, a combination of being put into service long before up to design capacity girth, four spacecraft on

the structure anyway between ground and GEO, and severe rain lateral loads from rainstorm across a hundred kilometers of KESTS atmospheric tubing. Signing the facility log, he then stepped onto the tunnel tramway and headed for the tunnel entrance, and out into the storm along the rocky path to home.

As part of the emergency on-site team, Techerson's wife Nona had spent the time at the lab in the home shelter, monitoring Techerson's progress and biosigns caringly, the telemetry signals were all she had for the moment of her lover, as he had headed out for the emergency repair task. Setting the voice com between Techerson and Houston Control to speaker so she could listen for any alerts for her, then decided to spend the time on her pet project, the Holoterminal prototype she was building and testing as she went along, designing and building creatively, more by intuition than by much advance planning. The Holoterminal was her lifelong dream, something she seemed compelled to create, the basic lure was there even in her childhood play expression. It was shaping up as part of the KESTS maintenance system, at least in her imagination so far. The vision was to experience being the KESTS as if it was one's own being, in all its aspects. To grasp the wholeness of the KESTS then flow consciousness into whatever parts were of interest each instant, look as narrowly deep or wide as one chose in the flow. She hoped that the Holoterminal would obsolete the data readouts and computer data displays and colored lights all with their messages that still had to be put together by the maintenance technician so as to provide meaningful direction to the tasks. The Holoterminal, she intended, would convert the sensors of the KESTS far-flung trackways and live loads, billions of data bits each second, into something that could be perceived as part of oneself, each stimulus bonded with its meaning, patterns pre-processed as needed. She had gotten the

specific approach she now compulsively used, long ago when meditating: be a rose, what are your petals like, your stems, your roots, the garden you are in. Decades her creative mind gathered pieces in mind of what might be put together to achieve the result of a dynamic machine communicating into a person's "being" picture. That everything is interconnected into a web where everything affected all other things, a sneeze shook the universe ever so lightly, and she had found how a machine's "sneeze" could be felt by a person. She just knew that this would be useful, make life more interesting and effective, for maintenance purposes as well as other fascinating uses she only felt luring her from the depths and heights of existence.

A moment's attention to the com panel and the ongoing chatter between Techerson and Houston, not likely things would need her attention there for a few moments, so she sat into the crude holoterminal, its virtual spatial fields blooming into her mind like fog burning off to reveal the view beyond. Blended seamlessly with the signals from her real eyes and other senses, she shut her eyes to totally be with the holovision, her experiment had only run a bundle of fiber optic cables from this terminal in their home, out to the maintenance room deep in the Andean mountain tunnel, where the transceptors felt out the maintenance room and the KESTS and the tunnel shaft, a few hundred meter radius sphere of awareness. Be a rose, how are your stems and thorns, your roots, your garden... she became the tunnel, the KESTS, the control room, Techerson was getting in the maintenance gondola for a trip out into the night storm along the KESTS nearly horizontal outer layer. The interaction between her attention focus and the subject of her attention seemed to make it glow with life, as if every part was eager to share its ongoing story with her. The KESTS was made up of thousands of

individual KESTS, all the same small cross-section, more layers of tubes made for ever expanding payload lift capacity. It had not been intended that by this time all the tubes would be the same as the original one that worked reliably a mere decade ago; they were to exponentially increase in girth for greater efficiency and simplicity, reliability. But money had run out for everything technological along with the economically recoverable petrochemical energy was running out for civilization, they had not been able to build the manufacturing facilities for newly engineered tubes every few months. Like the Space Shuttle 40 years before, they had to stick with the prototype that worked, make it the workhorse design for freight, if it isn't broken don't fix it type mentality. The interior of each KESTS tube glowed with dynamic life, the armature mass streams flowing through their hard vacuum inductive maglev tracks at 35 Km/s as they sped through the earth surface terminal and re-accelerator mass driver complex. Except for a cluster of tubes at 3 o'clock on the KESTS cross-section, they were dark. It was taking a lot of electrical power to generate the electromagnetic fields to divert the armature mass streams from the 15 tubes the sensors showed were blown out, 35 Km out over the Pacific Ocean. The fail-safe had begun the strenuous dump of the incoming mass stream for those tubes as soon as the failure was sensed by the KESTS monitoring system. The huge magnetically curved storage track area normally was used to hold only a dozen tracks worth of armature mass streams for routine maintenance on the armature segments.

Stepping out of the Holoterminal prototype, she went into the kitchen and poured another cup of coffee. A glance at the kids' room monitor showed they were still asleep, OK. Much like their coffee grinder, she set the coal grinder to pulverize enough to provide for the unexpected load of the maintenance problem on the

KESTS, the pulverized coal being fed to power turbines that ran their emergency electric power generators whenever their oil fuel energy allotment was exceeded, like now. Some of the energy also went to charge their car's battery, although pulverized coal dust provided most of the energy during the long run down the mountain to get food and supplies once a week. She charged up the car's batteries as much as possible, the stationary electric power plant had scrubbers to collect much of the coal's mercury and sulphur, unlike the car's system, too energy-intensive for efficient pollutant scrubbers. She tried not to think of the pollutant effects of each weeks' drive in their coal-powered car to get supplies, statistically added to the worldwide similar usage, their trip would cause neurological damage to one human child, destroy half the leaves of a tree in a forest, and teeter several life forms a bit more toward extinction; yet, theirs was a mission of mercy, if the KESTS got a solar power plant up in time, the pathway to GEO for building all the electric power plants the world needed for electric power would be begun, and coal fired turbines would be a thing of the past, and healing could begin. If they failed, they would only have speeded up ecological ruin a small amount.

Introduction to the background technology papers

These adventure stories play out in scenarios formed by the Earth's surface, its Geostationary Earth Orbit, GEO, that is some 22,300 miles above the Earth's equator; and the space between, including LEO, Low Earth Orbit. The major technological concepts, as described more fully in the sections below, include the PullBand Ground Commute system; the classical wheel-type space station in Low Earth Orbit; the anchored tether Space Elevator, both of the tapered constant stress cross-section type, and of the constant cross-sectional-area type; the integrated education-manufacturing residential workstation, and the hoop-shaped Earth to GEO transportation lifting structure, called the KESTS (Kinetic Energy Supported Transportation Structure) or the Carousel Space Escalator.

Much of the potential of the usage of this space is discovered when realizing the very low innate cost of moving things between the ground and GEO, the energy cost; that is the energy that is added to payload by moving it between the two different heights within the inverse-square gravitational force field. This energy is far less than is assumed when observing the enormous energy expended by conventional rocket launch vehicles when putting payload into GEO, and the contention here is that there are potentially other far more efficient ways for doing this particular task, that of moving payload between ground and GEO. The energy given to the payload's mass by moving it from the ground up into GEO is 7.3 KWh per pound, which, if electricity costs 10 cents per KWh, is only $0.73 per pound. Compare that with conventional rocket costs to do this job, $10,000 or more per pound. With an

adequate transportation system that approaches the \$0.73 per pound transportation cost, the potentials for utilizing space become enormous.

Here is how one can determine that energy cost to move between ground and GEO: first, as a check point value for the energy, we know the energy given mass to reach GEO has to be less than that given to mass by giving it “escape velocity”, the speed with which launched straight up it will never return. That is about 25,000 mph, 1.12e4 m/s. For a pound or 0.454 kg given this velocity, it takes $E = 0.5MV^2$ = 2.84e7 Joules of kinetic energy which is equal to 7.9 KWh. At an electrical energy cost of 10 cents per KWh, that is 79 cents of energy given to the one pound mass in accelerating it so fast it will never come back (if there were no atmosphere to punch through, of course) and clearly to go into a lower altitude it receives less energy than that; so this gives us a calculation check limit: to lift up to GEO, has to be less than 7.9 KWh per pound mass.

To calculate the energy needed to lift between two different altitudes in an inverse square gravitational field, measured in Joules, is
$E = GMm((1/R_0)-(1/R_1))$ = 2.4e7 Joules/lbm
where G is the gravitational constant 6.67e-11, M is the mass of the planet or moon, Earth in this case has a mass of 5.97e24 kg; m is the reference mass of 1 pound mass in this case, or 0.454 kg; R_0 is the radius of the lower altitude, 6.378e6 meters in Earth's case; and R_1 is the radius of the upper altitude, GeoStationary Earth Orbit 4.23e7 meters. A Joule = 2.78e-4 Watt-hours, so the lift energy equals 14.7 KWh per Kg or 6.7 KWh per pound in the vertical lifting up to GEO altitude; then to give the mass a sideways push to have an orbital velocity of 3.07 Km/s at that altitude, again from
$E = 0.5MV^2$ = 2.14e6 Joules = 0.59KWh; adding the

two energies together = 7.3KWh per pound mass to move it from the ground (at the equator) up into GEO orbit. Again, that's about 73 cents per pound lifted into GEO, at 10 cents per KWh.

So, lets look at the concepts involved in these stories in more detail. They include:

- The PullBand Ground Commute System
- The Anchored Tether Space Elevator
- The Centristation Toroidal Space Station
- The Home Manufacturing Education Workstation
- The Kinetic Energy Supported Transportation Structure to Geostationary Earth Orbit
- Application Facilities in GEO

The PullBand Ground Commute Concept

The Novelway Prototype Shop short story led into the transportation focus of these sci fi stories, with the story of the giant redwood trees having a social consciousness extending back eons, and had decided to put a new dream onto this upstart species called humans, who were unwittingly destroying the life-sustaining environment. They start off with a more energy efficient ground commute concept as utilized in the development of the short story.

The technical writeups on this concept are included below, as re-written after all the author's technical files were taken from his home by persons unknown in the mid-1980's, after the author had attempted to get corporate interest in creating the concept.

Below is the writeup I made of the concept in 1995 on my early earthlink.net/~jedcline web pages:

A High Efficiency Ground Commute System Concept

by James Edward David Cline

ABSTRACT

This is to suggest utilizing some of the surplus aerospace capacity for creating a backup ground transportation system technology. The concept was an outgrowth of the gas station lines of the early-70's, with its spectre of losing all crude oil imports from other countries, and the transportation energy crisis resulting in our widespread form of living. The concept grew from speculation on what could be done with existing resources if cars could not generally be fueled

anymore: how to get the commute function going again. From there the concept evolved into one in many ways superior to the existing commute system based on automobiles etc. It preserves the individual vehicle ownership and possession feature of our customary way, yet uses a distributed energy technology which greatly reduces the vehicular mass, and has inherent automatic guidance and routing functions.

It may be easier to convey the concept by describing its evolution from that hypothetical situation where all crude oil imports cease indefinitely.

The basic technology might be labeled "Pull Band" transportation, in that its most rudimentary forms consists of a person grabs onto a moving rope or moving metal band, and is pulled down the street by it, as the person rolls along on roller skates or other wheeled support. The ropes or steel bands would be in a continuous loop around each city block, and powered by the then surplus car engine scrap pile. From that humble, get-system-going-again start, the concept evolves into a Pull Band commute system where multiple pull bands of increasing speeds pull streamlined lightweight shells of wheeled vehicles containing the commuter(s), accelerating into interstate environmental tubes with moving air and air bearings supporting the shell vehicles at velocities in hundreds of miles per hour.

Creation of a High Efficiency Ground Commute System Concept:

Could we have a commute system that has the convenience time efficiency of personal automobiles while also having the energy efficiency of mass transit systems? How could it be done?

As I sat in the long gas lines circa 1974-75 in Northridge, waiting for my share of scarce gasoline to run my car, I pondered that question a lot. Other questions were centered around the wisdom of spending some 80 billion dollars a year for foreign oil, which we just burned up in cars and power stations, and then we had, as a nation, pay for it with our very real estate, the only thing they wanted in return. But real estate remained, while oil was burned and gone forever. Was this wise?

So I began to create scenarios in my mind, there in the captivity of the gas lines, and later. What if all the oil were to be permanently shut off from foreign sources? How would we as a country cope? How would we get to work? With no gasoline for any personal cars, merely for trucks and pre-existing busses, how would the Los Angeles area get back functional again, with people again able to go to work and the grocery store?

There seemed to be a lot of possible ways to explore. I consider such problem by use of analogs. Qualities of ski lifts, cable cars ... a cable could move around each residential block, driven by efficient stationary engines, and upon which people could grab onto and be pulled down the street wearing roller skates or some other small wheeled gadgets, a skateboard maybe. Letting go to coast across each intersection, to grab onto the moving cable or belt there, continuing on down the street. And maybe a bit further into the street, a cable or belt could run at a higher speed go for many blocks before reversing direction in its own endless loop; a skated person could grab onto faster moving belts from a slower one. Then when approaching destination, reverse the process to ever slower cables or belts, finally to let go and be on the sidewalk next to one's home or one's workplace. Such an emergency starting place for a ground commute system might work, get the

area up and running in mere weeks, perhaps. For intercity runs, trains, busses, ships and airliners would provide the long hauls at first, even of lightweight shell vehicles used instead of just skates.

Years went by, and occasionally an idea would occur to me as to improvements and expansions of that idea. Whenever I could get someone to listen, I would tell them of this concept: it seemed important that the country get freed from the burden of 80 billion dollars burned up each year as imported crude oil, unrecoverable, and often paid for by selling our real estate to non-Americans. But I could not figure out how to get others interested enough to build a prototype system, or how to even contact people who could do something about it. I even attempted to write a fiction story which involved the concept, in outline form, "Unfinished Transportation Story" .

I stumbled onto an employment ad from a major automobile research facility in the area, and so wrote my concept up and sent it to that personnel office asking it be forwarded to the appropriate R/D office. They never acknowledged my offering; although strangely several weeks later I discovered that my files had been pillaged, and my copy of that letter had been stolen as well as everything I had written on the concept prior to then, except that unfinished transportation story... even my computer, an obsolete Coleco Adam computer, had its transportation concept files all gone except for that attempt at a fiction story involving the pull cable commute system: apparently somebody was interested in my concept, but not to my benefit. Life was tough for me already, and this was just one more problem; I stopped further conceptualization on it since that clearly would merely invite more expert burglaries of my files.

By then the concept had grown and improved to use thin stainless steel belts around each residential and business block, to provide the pull power to the individual vehicles, which would be lightweight wheeled streamlined shells normally garaged at one's home, just like cars are now. These shells would be pedaled from one's garage to the adjacent street, where it would clamp onto the first speed level pull cable or belt. The person now rode in this shell wheeled vehicle, not on skates as the original idea would have used at first. Thus it provided shelter from the environment during transit, and a secure place for belongings while out shopping later, just as a car does.

This vehicle would switch to a faster adjacent pull band/belt, to cross intersections and ease the commute; the clamp shift between pull-bands would be mechanized and shock absorbed to minimize the abrupt changes in speed at each switch to a higher or lower speed pull band. If the vehicle had a very long way to go, it would switch out to further pull bands fast enough so that the vehicle could now air-sled on the surface of an enclosed commute tube, with the air column going in the same direction as the stream of pulled vehicles, very high velocities could be efficiently achieved, perhaps over a hundred miles per hour or more.

The sequence of clamp shiftings could be automated, entirely guiding the passage of the vehicle with a sleeping passenger to its destination, then awaken the passenger. With such lightweight shell vehicles, ramps could be built up sides of office buildings, enabling direct access to one's office from one's vehicle parked right outside the window... or door in newly designed office buildings.

For families, a standard shell built for a maximum of two people would be connected to a second such vehicle for children or elderly family members to ride in, like a trailer vehicle.

The power to drive all these moving cables/belts/bands initially could come from anything that could do it, such as committed optimized engines removed from the obsoleted automobiles. Or steam engines, or electric motors; whatever could do the job.

Returning to the Los Angeles area from Northern California, I finally got a survival level job, in a car alarm manufacturing company. I toyed with the idea that the country ought to develop such an emergency backup transportation technology, and mothball the tooling for it as a backup in case of the feared total loss of foreign oil supplies; but who to write to about this? One person suggested getting a grant, somehow.

And one day the newspapers had an article about some competition for technologies for a new commute system for Los Angeles, trains vs busses, conventional light rail systems. A councilman in a nearby area was quoted, which I interpreted as being someone who might be interested in my concept, which ought to be looked at, even though no hardware had been developed yet. My letter outlining my concept to him, address gotten from the phone book based on the newspaper article, was returned, with scribbled note on the opened envelope that the person (a lawyer in the phone book) was not really the person quoted in the article. Again, a shut door. Later a newspaper article quoting Mayor Riordan as desiring to choose to consider only well-proven technologies for a transportation system. Then an article saying a 6-billion dollar contract had been let for a light rail system... big money! No wonder the burglaries of my files, someone

couldn't risk people knowing that there were possible alternatives to established expensive inefficient mass transit systems.

But still it seems wise that we, as a country, do design and build prototypes and tooling for such a high efficiency, fully useable in widespread cities like Los Angeles, and store the technology for a time of immediate need. This could be done even without disturbing the ongoing plans for mass transit systems now being built. And then perhaps the pull-band high efficiency commute system could be built into new retirement suburbs, where it could be proven out in real usage. Eventually somebody would recall the 80 billion dollars in foreign oil we wasted each year, or maybe consider that oil reserves are better saved for future chemical feedstocks ... and install the pull-band commute system throughout the city, the country. Thus we would have the energy efficiency of mass transit systems, and also the door-to-door time efficiency and convenience of automobiles, finally.

Anchored tether space elevators

Background: the author was but one of many who independently thought of the concept of the anchored tether space elevator, supported by the 24 hour rotation of the Earth swinging a tethered counterweight around as it rotates, thus supporting the tether as it reaches into space (the author thought of it in 1969, although turns out that it was first described by Artsutanov, a Russian, in 1960, long before that; and in American literature by Isaacs et al in 1966. I was unaware of them when I thought of the idea, too.)

Nevertheless, my calculations of strength to weight ratios of potential tether materials showed that there was no nearly adequate tether material in existence, by a huge difference. The strongest natural material at the time was the fiber of hemp rope, far stronger than steel for its weight; and the strongest man-made material for its weight was vacuum-processed fiberglass, at a half million pounds per square inch tensile strength when made and kept in a gas-free environment.

However, the Moon was already known to have natural glass abundantly on its surface, and so the author came up with the Mooncable Project concept of an anchored tether space elevator anchored on the Moon and supported by the counterweight dangling toward the Earth, weights balanced across the L-1 balance point between the Moon and the Earth, with a little bit extra weight on the Earthward end to make sure it stayed held in place. So let's start with the Mooncable writings of the 1970's and 1990's, and then progress to more recent space elevator designs based on the theoretical carbon nanotube tether material which would be adequate to utilize a non-tapered cross-section tether for an Earth Space Elevator, next.

The Mooncable Project

Background text; reformatted 1972 proposal and NASA reply; GEnie writeups in 1990-ish

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The following is a re-formatted pair of documents, the first is the document the author wrote early in 1972 and was sent to NASA for consideration (naively) and is followed by the reply received from NASA in mid-1972. The author believed it would make a fine follow-up space project after the Apollo project, which was nearing its conclusion at the time.

THE MOONCABLE: A PROFITABLE SPACE TRANSPORTATION SYSTEM

March 25, 1972

James E. D. Cline
905 Old Topanga Canyon Road
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Abstract

The theoretical basis and major engineering concepts of a unique space transportation system are being presented. It is intended primarily for bringing Lunar and space-environment commercial products to Earth at potentially very low expense on a long-term, high mass payload, continuous operation basis. Viewing, the moon and Earth as two adjacent, partially merging gravitational pits in space, a tensile structural attachment to the Lunar surface is constructed in the saddle between the two pits of such dimensions as to remain in place supported by the upper part of Earth's gravitational pit. Masses descending down the tensile

structure, or cable, into the Earth's pit are slowed by electromagnetic braking against the cable, exchanging gravitational energy into electrical energy. The electrical energy is transferred to a conductor system on the cable, which is preferable superconducting by use of sun ward layered foil reflectors. The conductors carry the electrical energy across the gravitational hump to the moon-ward part of the cable, where electromagnetic traction motors exchange the electrical energy back into gravitational energy, lifting payload up from the Moon. The strength limitations of existing engineering materials are overcome by the creation of a constant-tensile-stress concept, which makes all parts of the structure carry an equal load by appropriately varying its cross-sectional area along its length. To show that it can be done, an example cross-sectional distribution has been worked out for a cable of 10E4 lbf lifting capacity from the Moon's surface, requiring a maximum area of 21 in2 at the zero-acceleration point between the two pits, and shrinking to one-hundredth that area at the point of contact with the Lunar surface. The structural material used in the example is silica fiberglass, due to the abundance of silica on the Lunar surface, and assumes a strength of 5E5 lbf and a safety factor of 2. The emplacement of the resulting large mass of cable is made feasible by the concept of a "growing" cable, starting from a "seed" filament brought from Earth, and progressively increased in area by electrically raising new fiberglass up from an expanding fiberglass manufacturing automatic plant on the Moon, ever-increasing the lifting capacity of the cable. The initial fiberglass-producing plant landed there probably would be between the size of Surveyor and Apollo.

With the efficiency allowed by using superconductors, the Mooncable theoretically can transport payload from Luna to Earth at zero energy

cost, and actually may be able to provide a surplus of electrical energy during this transportation process, depending on the length of the cable. Initial Lunar and space environment products for import to Earth markets involve zero-g foamed-steel and foamed ceramics cast into glider shapes with cargo compartments to be dropped off the end of the "Mooncable" into Earth's atmosphere.

The structural mass of very large spacecraft for extensive space exploration, made of Lunar materials, can be lifted up out of the Moon's gravitational pit at an estimated 3 cents per pound, using externally supplied electrical energy from a small nuclear-electric powerplant on the Moon or on the cable for this function.

Purpose

The purpose of this document is to disclose the fundamental concepts of a unique category of transportation in space, which may enable our declining space industry to revive by creating a system continuously transporting large quantities of Lunar environment products to Earth markets at negligible cost.

This document will be limited to a brief presentation of the fundamental transportation concept along with one set of engineering concepts which might be used to implement the system.

Materials and other products from the unique space and Lunar environments, such as "foamed steel" would be marketable profitably if the cost of bringing them to Earth markets were sufficiently reduced. Foamed steel is expected to be a building construction material of outstanding usefulness.

Chemically-fueled fueled rocket propulsion transportation, such as used by the Apollo project, is too inefficient to provide inexpensive transportation to market, because nearly all of the fuel energy is used just to lift the fuel mass itself.

An alternative Lunar-Earth transportation system concept is now being proposed, which potentially can reduce the transportation energy cost to a negligible expense, although some of the features of the concept stagger the imagination. No chemical energy fuels need be brought from the Earth to the Moon, or be made on the Moon. It is necessary to the understanding of the concept to change one's visualization of what lies between Moon and Earth. Analogously imagine a small model of two adjacent pits in the ground, the shallower one containing water. Then note that the water from the shallower pit may be siphoned into the deeper one without addition of external energy, provided that a hose is provided and the siphoning process is started.

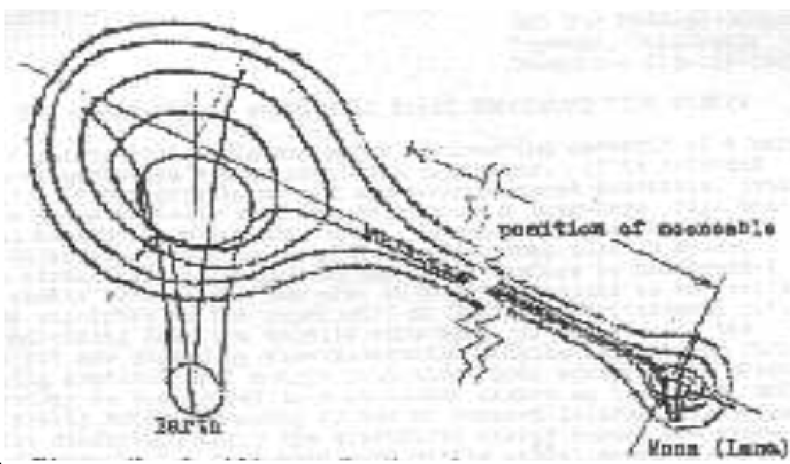

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Figure No. 1:
Adjacent Earth and Moon Gravitational Pits

Such a siphoning process will power itself provided that the work applied to the mass being transferred down the deeper slope is greater than the work required to lift the mass up from the shallower side. The Earth and its moon, Luna, may be pictured as two adjacent gravity pits in space, the pit corresponding the the Moon being much less deep than that of the Earth.

The total work of lifting mass from R0 to R is the area under the curve representing the force of gravitational attraction,

$$W = \int_{R_0}^{R} \frac{GMm}{r^2} dr = GMm\left(\frac{1}{R_0} - \frac{1}{R}\right)$$

The work involved in getting in or out of the Moon's gravity pit is 2.9E6 joule per kg, or 807 watt-hours per Kg. Similarly, the work energy received going down Earth's gravity pit is 6.2E7 joule per kg, or 17.3 KW-hr per Kg. Also, in going from the Moon to Earth an orbital kinetic energy of 140 WHr must be given up. The resulting algebraic sum of energy is 16.5 KW-hr per Kg surplus energy. Therefore, a siphon-like process could continuously move Moon-mass payload to Earth without further input of energy, theoretically.

A siphon-like process can analogously be formed by a continuous balancing interchange of electrical energy and gravitational energy between masses going up and down gravitational slopes. Electrical energy can be converted into gravitational energy such as by an electric traction motor powering an attached payload up a cable; gravitational energy is converted to electrical energy by a payload pushing a traction-coupled electric generator down a cable; and electric power is coupled between up- and down-moving masses by electrically conducting tracks along the cable.

A cable, or other tension structure, if it is attached to the Moon's surface and extends up out of the Moon's gravity pit toward Earth far enough so that part of it hangs down part way into Earth's gravity pit, will stay there in place without external energy applied, if the weight of the part of the cable in Earth's pit is at least as great as the weight in the Moon's pit.

A constant cross-section tension structure, such as a common rope or cable, must have a tensile strength-to-density ratio which excludes most known engineering materials. However, a "constant-tensile-stress" structure concept produces a varying cross-section cable which easily has sufficient strength for this purpose, being larger in cross-section where tension is greater in the cable.

This tension is greatest at the point where the Moon-Earth gravitational accelerations with the angular centrifugal acceleration cancel out one another, and is less than the tension bearing the weight of an infinitely long cable extending out from the Moon's surface.

To prove that a constant-cross-section cable can be strong enough for this purpose, an imaginary cable extending from the Moon to infinity was divided into sections of constant-crossection area, the area of each section being that required to support the weight of that section plus the weight of the cable below it plus the attached conductor weight and live loads, expressed by the following equation:

$$F_{n+1} = (A)(S) = \frac{(F_n)(S)}{(S) - (d)(r_0)(\frac{1}{6g})\int_{r_n}^{r_{n+1}} \frac{1}{r^2}\,dr}$$

Where Fn = Force atop a section of cable
Fn+1 = Force atop next higher section of cable
S = working tensile stress of cable material
d = density of tensile material
r0 = radius of planet or moon

An outside figure for the mass of an example rope was determined by applying the above equation in 23 cable sections to find the maximum required cross-sectional area at infinity. The assumptions were:
(a) A maximum upward pull on the Moon by the rope of 2.5 X 10E4lbf (1.1 X 10E5 newtons)
(b) A niobium-copper superconductor constant-cross-section equal to a pair of #12 wires,
(c) A maximum live load force lifting an object from the moon of 10E4 lbf (4.4E4 newtons)
(d) A density of 8.3E-2 lbm/in3 fiberglass
(e) A working tensile stress in the fiberglass of 2.5E5 lbf/in 2 which assumes a strength of 5E5 lbf/in 2 and a safety factor of 2.

The resulting cross-sectional distribution is shown in figure 2.

The length of the cable will be less than that distance between Moon and Earth, 3.8E5 Km; and the average area will be less than that of the maximum if at infinity, which is 21 in2 (1.3E-2 m2). With a glass specific gravity of 2.3, this makes a mass of 2.6E9 lbm.

Raising this mass from the moon is made reasonable by using a special construction technique of using an initial filament brought from Earth and emplaced by chemical rocket transportation. This filament is gradually built up exponentially in dimensions and strength by electrically raising the fiber being added as it is made by an appropriately growing glass manufacturing plant on the Moon. Earth-launch

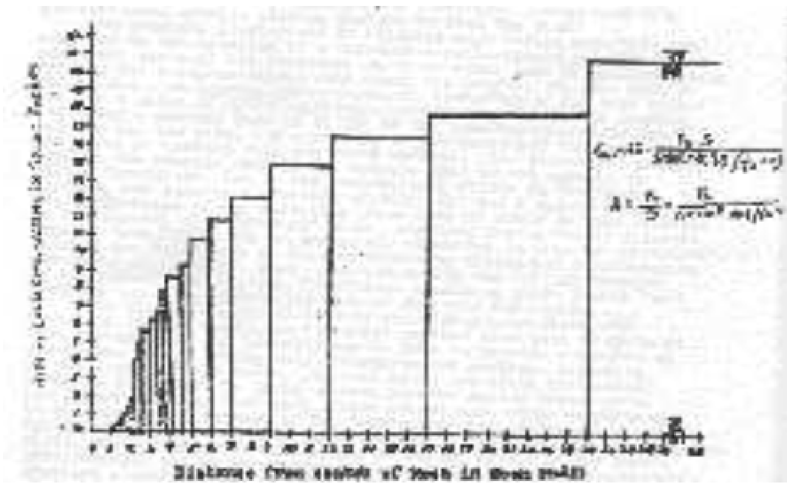

Figure No. 2:
Cross-sectional area distribution of approximated "constant- tensile-stress" cable extending to infinity, and having an input load of 2.5X104 lbf pull on the moon

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mass of the "seed" fiberglass filament, starting with two strands at the Moon's surface, is 2.5E4 lbm if 5E-4 inch diameter fibers are used, or 4.4E3 lbm if 1.5E-4 in diameter fibers are used. This does not include weight of reels, control equipment, and auxiliary equipment.

Assuming nuclear-electric energy at the Moon at a long term average cost of 10c per KW-hr, the energy cost of raising this rope's or cable's mass is less than 10E9 KW-hr, or 10E8 dollars, assuming also that the conductor is superconducting at the major phases of construction, and that generator efficiency is 99%, and an average electric traction motor efficiency of 91%.

The fiberglass is manufactured from the silica so plentiful on the Moon"s surface, making it the ideal

cable material. Heat energy needed to melt it may come from solar reflectors. Mechanical energy needed to form the fibers may come from the use of solar energy being used to expand a gas, or from the nuclear-electric powerplant. The size of the initial glass plant accompanying the emplacement of the "seed" fiber filament cable may be similar to that of the Surveyor spacecraft which were soft-landed on the Moon many years ago. Earth-made parts for later larger glass manufacturing facilities would use the partly-built rope or cable to reduce the cost of transportation to the Moon. The manufacture of strong fiberglass filaments would be greatly assisted by the vacuum so plentiful on the Moon, since contact with air reduces fiberglass strength during manufacture on earth. Space-rated fiberglass rope was for sale several years ago with a strength of 5E5 lbf/in2 so a working tensile stress in the rope of 2.5E5 lbf/in2 was used in the preceding example rope calculations, using a safety factor of 2, which is very conservative compared with a safety factor of 1.6 normally used in construction practice. The total mass of the rope needed would go down rapidly when the working tensile stress allowed is increased. Glass fibers drawn and baked in a vacuum have been measured as strong as 1.8E6 lbf/in2, so there is a good possibility that, for a given maximum payload lifted, the size of the cable may be greatly reduced over the "outside" value determined in the example calculation.

The area of the mooncable's cross-section would best be distributed in the form of a net or thin hollow tube, to prevent the cable from being completely severed by smaller hurtling objects. The conductors would best be distributed around the tensile supporting structure for the same reason, allowing continuous power for repair activities, and for bidirectional traffic during normal use of the system. A widely distributed cross-section would also help in case the mooncable

was ever severed, helping increase the amount of atmosphere which dissipates the falling cable's mass energy.

The Conductor and Motor Types

The conductors would need to be superconducting to enable the energy balance equations to approach reasonable accuracy, avoiding resistance heating losses in the conductor. Multiple layers of reflecting, insulating foils kept on the solar side of the rope may be sufficient to allow radiation losses to adequately cool the superconductors. The conductors might be still further cooled by having each tractor spray the conductor with cryogenic liquids from "lunar cryostats" during each passage along the rope.

The configuration of the conductors might be in the form of linear stripes for rolling or wiping electrical contacts to drive conventional traction motors, or spiral for use in a linear electric motor system. Direct current is assumed to be used, as the hysteresis loop in hard superconductors prevent the use of alternating currents and linear induction motors. If the conductors are difficult to cool sufficiently to be superconducting, energy losses would need to be minimized by using high voltages between conductors. A-C linear induction motors or conventional electric track propulsion concepts apply during the climb up the cable, with conversion of the motors to generators during the fall down the other end of the cable. Additional electrical energy might need to be supplied from nuclear-electric or solar-electric powerplants along the rope or on the Lunar surface, to overcome conductor resistance losses. This would still be high-efficiency transportation, requiring no chemical energy fuels to be made on the Moon, or to be brought from Earth.

Application of the System

The path from the Moon to the Earth is interrupted by the gap from the end of the mooncable to the surface of the Earth, so one way of bridging the gap is to modify the form of the larger imported products, such as the foamed materials, into shapes that can independently survive the drop into Earth's atmosphere and landing. For example, the importation of "foamed steel" might be made possible by lifting Lunar siderite steel up the cable to the zero acceleration point where it would be melted in a solar- reflector furnace and foamed into a mold which casts it into the shape of a giant low-density glider which then continues along the cable to Earth-end, where it drops off it into Earth's atmosphere into the ocean where it would float until collected, or glided under control to more accurately determined market sites for delivery to foamed-steel purchasers or conventional steel producers around the world. This steel operation alone may be able to support an expanding space industry, with the other space environment products being extra value. The "mooncable" also could lift the bulk of immense spacecraft, made of lunar materials, to the zero-g potential point on the cable for assembly and launching toward ambitious space exploration efforts such as a manned landing on Mars or collection of gasses from Jupiter's atmosphere, and perhaps an exploratory trip to a nearer star.

(Incidentally, Mars' two moons Phobos or Deimos could be used in a similar way in bidirectional transportation between Mars and points distant from its concentrated gravity field by electrically powering elevators operating between moon orbit altitudes and several miles above Mars' atmosphere, although a running start of about 1000 mph would be necessary to catch the end of a rope attached to Phobos, and much

less if attached to the more distant Deimos.)

Summary

This document has presented a concept of a new category in space transportation, along with some of the engineering concepts which could be applied to implement and use the transportation system. The ideas contained herein are hoped to be both the starting point and the goals for the labors required of the many talented and imaginative people who are needed to make the transportation system a reality. But it can be made a real, working, and useful system only if the people who create it are determined to make it work.

Author's notes:

Figure 2 shows the graphed values of several months of calculations made in spare time, with only slide rule, pen and paper. Although desk calculators and even a pocket scientific calculator, the HP35, existed in that time, none of these were available to the author at the time. There was a mathematical error made, obvious when graphed in figure 2, made at about 2 lunar radii; but since the purpose of the document was to show that a real and plausible value for maximum cross-section of the space-rated fiberglass Mooncable did exist, and since the error merely made the cross-section look even larger than the accurate value, the months of tedious hand calculations were not repeated, since the purpose of the calculations were fulfilled.

The above reformatting was done in Appleworks on 2003 04 11 by J E D Cline, using the earlier reformatting done for the home.earthlink.net/~jedcline/ website in 1998. James E.D. Cline

(NASA's Reply to Mooncable Follows. This is the response made by NASA's Invention and Contribution Board in response to the early effort to create a Mooncable Project. James E. D. Cline)

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Washington, D. C. 20546
Reply to attn of: KB

June 23, 1972
Mr. James E. D. Cline
905 Old Topanga Canyon Road
Topanga, California 90290

Dear Mr. Cline:

Your letter of June 3, 1972, which was addressed to Dr. George M. Low, Deputy Administrator of the National Aeronautics and Space Administration and which briefly described your concept entitled "The Mooncable: Gravitational-Electric Siphon in Space", was referred to the Inventions and Contributions Board for review and reply. We are also in receipt of related correspondence and a document entitled "The Mooncable: A Profitable Space Transportation System", which was forwarded to this office by Mr. Monte Mott, Patent Counsel of the NASA Pasadena Office. A review has now been completed of all of your material that has been received, and we should like to provide you with the following explanatory comments and suggestions.

The proposal which you have outlined in your correspondence is obviously conceptual in nature, and describes a project which, if undertaken, would involve

a significant expenditure of time and money to transport materials from the lunar surface to the earth. For your information, the lunar landing of the Apollo 17 mission which is now scheduled to take place in December, 1972, will conclude NASA's program to investigate the lunar surface, at least so far as the immediate future is concerned. Following termination of the Apollo program, we shall move on during the remainder of this decade to the Skylab program and subsequently, to the Space Shuttle program. You will find enclosed a copy of NASA EP-81 entitled: Man in Space (Space in the Seventies), which explains how NASA plans to accomplish the objectives of these programs. Present and future budgetary commitments to attain the goals outlined in this booklet will not permit the consideration of expenditures for extensive new projects such as the one you have submitted, and we are therefore not able to make a favorable recommendation with respect to your proposal. In your letter to Dr. Low, we inferred that you were requesting that NASA contribute funds for the promotion of the project you have proposed. We believe you should be aware of the regulations that apply to joint projects involving the expenditure of NASA funds and, for that purpose, are also sending you a copy of a NASA booklet entitled "Guide to Policies and Procedures for Sponsored Research" which we believe you will find informative and helpful.

The successful completion of the concept which you have proposed would depend upon the verification of a number of unsubstantiated assertions that are made in your presentation, and there is, of course no certainty that such confirmation could be established. This is an additional and important reason for deferring consideration of your concept. Although we cannot make a favorable recommendation in response to your proposal, we do want to thank you for permitting us to examine its contents, and to express our appreciation

for your interest in contributing to the advancement of NASA's future program.

(signed)
Francis W. Kemmett
Director of the Staff
Inventions and Contributions Board

The Mooncable Project, as put onto Genie Spaceport Library files in 1988

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Number: 480 Name: INTRO TO MOONCABLE
Address: J.E.D.CLINE1 Date: 880707
Approximate # of bytes: 3780
Number of Accesses: 33 Library: 3
Description:

Introduction to purpose and general function of Mooncable project, which is a Lunar tether through L-1, made of Lunar fiberglass and carries a combined transportation and materials processing function on a one-way trip. Purpose is to supply massive amounts of Lunar materials to Earth markets and LEO.

Keywords:
Mooncable,transportation,historical,elevator,tether, Moon

INTRO NOTE TO MOONCABLE PROJECT PROPOSAL by J. E. D. Cline

Inexpensive homes being constructed of superior

structural materials made in free-fall vacuum from Lunar raw materials? A construction project in space to strongly challenge the ingenuity and daring of hard-working engineers, planting mankind's feet solidly in space? Would you like to see this happen? I offer an idea for your active support , with perhaps just such a potential. Please read it thoughtfully without preconception. It offers some chance for space exploration to commercially pay for itself from here on out.(...this idea has such great potential significance that too great a time delay may cause an inability of our technology to implement it in later years, or perhaps interest will have died too far by then.)

I am proposing a specialized space transportation system, intended primarily to bring large quantities of materials from the Moon to the Earth, and from the Moon into a low (Earth orbit) gravitational level.

Examination of the concept shows it has some very interesting properties. Elements of the idea are very old, the most basic comparable concept was used as long ago as when the first ape swung from one tree to another on a vine, to keep from having to climb down one and then climb up another.

A siphon has a more closely related characteristic, which transfers mass from a higher gravitational level to a lower gravitational level yet bringing it up through a higher gravitational level than either the starting or ending level.

Fundamentally, the transportation process converts the gravitational energy of a mass being accelerated by a gravitational field into electrical energy, which is then transfered across the gravitational hump, or saddle, which exists between the Moon and the Earth, and there the electrical energy is reconverted into

gravitational energy by lifting mass there. The spacial reference necessary for this process is provided by a tensile structure attached to the Moon and extending part way toward Earth. The stress on this structure consists of the weight of its own mass, the weight of the electrical conductors, and the forces due to the live loads on the structure, all extending through a varying gravitational field....

James Edward David Cline

Written April 27-30, 1972

Input to GEnie Spaceport July 07, 1988

The "Mooncable: Gravitational-Electric Siphon in Space" proposal will be uploaded to GEnie when condensed to a reasonable size.

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Number: 485 Name: MOONCABLE PROJECT
Address: J.E.D.CLINE1 Date: 880717
Approximate # of bytes: 16380
Number of Accesses: 22 Library: 3
Description:

An unusual, highly specialized space transportation concept was generated to provide a profit-making space enterprise. The concept offers highly energy efficient transportation of payload from the Lunar surface. Includes early calculations on a constant-stress cross-section cable.

Keywords: Mooncable,transportation,maglev

MOONCBL9

By J. E. D. Cline, July 16, 1988

The Earth's physical makeup has so many incredible coincidences that are needed for life to exist upon it, and The Earth's moon seems an extension of those coincidences in the possible extension of Earthlife into space. The Lunar tides of earth's oceans upon her beaches has stirred tidal life onto land from the sea; now the fact that the Moon always has the same face turned toward the Earth, and its relatively large mass near the Earth, show promise of a major stepping-stone for the extension of Earthlife into space. And the Lunar terrain is a potential source for raw materials for building space colony structures, closed-ecology very-large-spacecraft for exploration/colonization beyond the Earth-Moon system, and for exotic construction materials for use here on Earth such as foamed-nickel-iron-steel.

Space transport systems are necessary to transfer material and energy from where it is now, over to where it will be needed. Theoretically there are alternatives to the traditional reaction engine propelled vehicles which use energy stored in propellants. The energy differentials in space are another source of transportation energy. Picture the Earth and Moon as being two adjacent depressions in a gravitational field. The Earth's depression is much deeper than that of the Moon's, so it is imaginable that material might be "siphoned" from the shallower depression into the deeper one. Could an electromechanical analogy of a siphon be constructed to move raw materials from the Lunar surface over to a somewhat deeper level in the adjacent Earth's gravitational well, using the energy

differential itself to power the process?

The work involved in getting out of the Moon's gravitational well to L-1 is only about 800 watt-hours per kilogram; and going from L-1 to Earth requires each kilogram to give up about 16,000 watt-hours of energy, so there is plenty of energy to tap off for use in lifting mass up from the Moon to L-1. Of course, most of the 16.5 KwHr/Kg must be dissipated in the atmospheric entry process after the payload leaves the end of the end of the "siphon". With the end of the siphon-like electromechanical transport system extending deeper into Earth's gravitational well, surplus energy is produced which could be used to lift some of the payload up only to L-1, and leave from there with relative ease toward other parts of space near the Earth-Moon system. L-4, L-5, Mars and the asteroid belt, here we come!

[Calculation reference point: the work performed in lifting all the way out of a planet's gravitational well is the same as lifting out of a well which is one planet radius deep,with a constant acceleration the same as found on the planet's surface (reference Arthur C. Clarke's "The Exploration of Space" p.33), or

Work = G*M*m*(integral from 1 to infinity)1/(R**2) dR

As a hobby, by the end of 1971 I had worked out just such a conceptual system; then there were extra Saturn 5 Moon rockets available from the Apollo flights that were cancelled, and they could be used to emplace the "seed"electromechanical transport system. I called it the Mooncable Project. It would be a profitmaking enterprise through the sale of space-environment processed materials originating on the Moon, processed and fabricated at L-1, and delivered for sale

to Earth markets. Space exploration would henceforth pay for itself!

(But the reality was that NASA was at that time starving for funds just for the Space Shuttle project to be started soon; and anyway NASA was prohibited by charter from financially supporting profit-making enterprises... so said a letter to me from NASA's Inventions and Contributions Board on June 23, 1972. With no income from my efforts, my wife soon divorced me, and it became apparent that my advertising of the Mooncable Project had attracted the wrong kind of attention: I soon lost my house too and then my job...mere survival became my focus of attention from then on.)

The foundation analogy for this concept is that a siphon can draw water out of an aquarium without using a pump, and does it a lot easier than dipping it out by hand. Picture the Earth and Moon being two adjacent depressions in a gravitational field. The Earth's depression, or well, is much deeper than that of the Moon's, so it is imaginable that payload mass might be "siphoned" from the shallower well into the deeper one. Basically this means that energy given up by payload mass falling down Earth's gravitational well is used to perform the work of lifting up more payload mass from the Moon up toward the earth, thus forming a regenerative energy loop, self-sustaining, as is a siphon, so long as the output end is at a lower gravitational energy level than is the input end.

The work involved in getting out of the Moon's gravitational well is only about 800 watt-hours per kilogram of payload; and going from the balance point between Earth and its moon, L-1, to Earth requires each kilogram of payload to perform about 16,000 watt-hours of work during its decent to the Earth surface. So there is plenty of energy to tap off for use in lifting mass

up from the Moon to L-1.

The key is to find a way to transfer the energy from the descending mass over to lift the rising mass. One way might be to transfer energy electrically through superconductors linking the two masses; the superconductors could be part of a frictionless magnetic-levitation railroad track laid on a strong tensile structure coupling the two masses. Coupling the energy between payload masses would be tractor motor-generators magnetically coupled to the maglev track, pouring energy into the track while braking the fall of mass down the earthside end of the track, and consuming that energy by lifting more payload mass up the other side of the track. The Lunar surface spatial reference for this process is created by a very long tensile structure anchored on the Lunar surface and extending up through the balance point L-1 and over into the Earth's gravitational well. At the end of this document, the original calculations are shown which show that fiberglass is strong enough for this application, if it is formed into a constant-stress cross-section cable. Glass is one of the most abundant materials found on the Lunar surface, making it ideal for building this very large tensile structure.

To protect the mooncable from being accidentally severed by small hurtling objects, the area of the cable might best be distributed in the form of a net or pair of hollow tubes. The conductors would be distributed for the same reason and to allow continuous power during repair activities and to allow bi-directional traffic along the cable for the returning traction motor/generators and delivery of goods from Earth.

While at the null-g balance point L-1, the Lunar ores are processed into useable forms. Nickel-iron, aluminum, titanium, ceramics, and glass are foamed into large

molds, casting them into glider shapes for the atmospheric re-entry portion of the journey to the Earth's surface. Pockets in those gliders hold smaller amounts of more exotic materials processed in the space environment. Here at L-1, 64,000 Km above the Lunar surface, material is also launched out toward other sites, such as L-4 & L-5 for building space colonies, for building very large spacecraft for leisurely manned exploration of the solar system, and for building Solar Power Satellite powerplants. From L-1 a space tug would be needed to transport the material to L-5 or other sites.

The specific concept presented here is intended primarily for bringing Lunar and null-g vacuum environment commercial products to Earth at potentially very low expense on a long-term, high-mass payload, continuous operation basis. It should also be useable to supply the materials for constructing powersats (SPS), and the help supply materials for building colonies at L-4 & L-5 and large manned spacecraft for the further exploration of space. The general concept presented here is intended to arouse the readers' creative imagination toward seeking alternative paths for bringing mankind and other Earthlife into nearby extra-terrestrial space.

Addendum: at the time this concept was completed as a personal hobby activity, my only calculating tools were a slide rule and pen and paper. Believing that all I had to do was to show that an abundant material was capable for use in constructing the major portion of the mooncable, and then others with adequate computers would eagerly fill in the refinements, I set out set out to the disagreeable task of figuring out how to calculate the forces and configuration of the Mooncable. Making some outside limit observations by seeing the "big picture", I could more easily show that fiberglass was

strong enough for a related but even more demanding structure. The weight of the mooncable essentially is the same on either side of the balance L-1 point, even though the mass on either side wouldn't necessarily be the same due to the varying gravitational fields it crossed. So the structure just from one side, the Lunar side, was calculated; and it was easier to calculate from the Moon's surface out to infinity than to L-1, which I did not then want to calculate its location. My old college calculus books did not seem to have any applicable equations for integrating through varying gravitational fields, but I did find relevant equations in George Gamow's book "Gravity": the total work of lifting an object from R0 to some radius R, is the area under the curve representing the force of attraction:

Work = integral from R0 to R of (GMm)/R2) dr

= G*M*m*integral R0 to R (1/R2)dr

The integral of 1/r2 is -1/r: in general,

integral Rexp n dR = - (R exp (n+1))/(n+1), from Handbook of Chemistry and Physics. Thus the work "W" done is

W = - (GMm)/R - (-(GMm)/R0)

W = GMm(1/R0 - 1/R)

A constant-cross-section glass cable extending from the surface of the Moon and going an infinite distance away (ignoring the presence of Earth and other bodies), would experience a supporting tensile force at its far end of :

F = m*a

F = m*(1/68g)*integral from 1R to infinite R of 1/r2 dr

F = m*(1/6)*g*((1/1*R)-(1/infinite R)

F = m*(1?6)*g*(1/R)*(1/12 - 1/ infinity)

F = (1/6)*g*m/R

Now m/R is the mass of a length of one radius, and making the area equal to 1 square inch to make the results in engineering terms,

m = area * length * density

m = (1 in2)*(6.85 E7 inches)*(8.3 E-2 lbm/in3)

m = 5.68 E6 lbm

Returning to F = (1/6)*g*(m/R)/in2

F = (1/6)*g*5.68 E6 ;bm/in2

F = 9.4 E5 ;bf/in2

Since glass fiber cable has a strength of 5 E5 lbf/in2, it is only half strong enough for this configuration. It probably can be made strong enough, however, by controlling its cross-sectional area, with an optimum distribution of area with distance being that which creates a constant stress within all parts of the cable's volume.

My personal ability to manipulate the concepts of calculus confidently does not allow me to write and solve the equations required to easily derive the cable's dimensions for a given set of loads. However, I can show that a glass cable can be sufficiently strong by integration through summation of sections of cable,

each section having the same maximum stress, that stress being in a cross-sectional area great enough to support the weight of that section with its loads plus the force applied at its lower end supporting the weight below it.

The characteristics of each section are derived as follows; assuming each section has a constant cross-sectional area throughout its length:

The weight of cable in each section is

Fs = A*d*R* integral i/r2 dr

where Fs = weight of this section of cable

A = cross-sectional area of this section of cable

d = density of glass = 8.3E-2 lbm/in3

R + radius length of Moon = 6.85 E7 inches

The stress at the top of each section is the greatest stress anywhere in the section, and with a safeth factor of two is2.5 E5 lbf/in2. This stress is equal to the force on the cross-section divided by the area of the cross-section:

S = (Fs + Fl)/A

where S = stress at top pf the section = 2.5 E5 lbf/in2

Fl = attached load (bottom weight + conductor etc)

A = cross-sectional area of cable section

Expanded, this equation becomes

S = ((A*d*R*integral 1/r2 dR)+Fl)/A

Solving for Area A:

A = Fl/(S-d*R*integral 1/r2 dR

The force at the section top then is

F = A*S = (Fl*S)/(S-d*R*integral 1/r2 dR, or

Fn+1 = (Fn*S)/(S-d*R*(1/6)*g integral 1/r2 dR

The force, F, then becomes part of the attached load, Fl, of

the next cable section above it.

F0 = force pulling upward on Moon's surface by the cable

F1 = force atop first section of cable, and at bottom

of second section

F2 = force atop second section of cable and at bottom of third section, and so forth.

S, d, and R are constants:

S= 2.5 E5 lbf/in2

d= 8.3 E-2 lbm/in3

R = 6.85 E7 in

To make an example Mooncable calculation, some values will be somewhat arbitrarily assigned:

maximum upward pull on the Moon's surface by the cable and its loads is to be 25,000 lbf

superconducting maglev track will be equal in mass to two #12 copper wires, resulting in a mass of 2.2 E5 lbm per radius. When this becomes a hundredth of the glass cable's weight it will be left out of the calculations for simplicity.

the maximum force due to the live load will be 1 E4 lbf This would be something less than 6 E4 lbm on the lunar surface; it is a dynamic load.

Dividing the cable up into 23 sections, summing the forces atop each section, reached a value of less than 21 in2 at infinity, a realistic number. This shows that fiberglass cable does indeed have an adequate strength/mass ratio to do the job. Since the calculations were "outside approximations" the area would be less than this figure; also the attraction of the Earth on the cable, and the centrifugal orbital force on the cable would affect the full parameter calculations, while the mooncable lies in the saddle formed between two adjacent gravitational wells of the Earth and its Moon.

James Edward David Cline (GEnie J.CLINE2)

Van Nuys, CA July 16, 1988

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Number: 530 Name: MOONCABLE PROJECT 14

Address: J.E.D.CLINE1 Date: 880909

Approximate # of bytes: 25200

Number of Accesses: 24 Library: 3

Description:

This concept offers highly energy-efficient transportation from the Lunar surface, processing at L-1, and delivery either to Earth-surface markets, or to spacetugs at L-1 bound for L-4, L-5 or elsewhere. BASIC program included for calculating cable sectional area vs distance, demonstrating adequate strength of lunar fiberglass in constant-stress-cross-section form. Also suggests directions for future concepts.

Keywords:
Mooncable,lunar,transportation,maglev,superconductor,
gliders

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file MOONCL14   THE MOONCABLE PROJECT2

By J. E. D. Cline, SSN [not shown], Sept 09, 1988

ABSTRACT:

In addition to enabling supply of large quantities of space-processed materials such as foamed-steel to Earth markets, this transportation system concept would have the added benefit of making available enormous amounts of cheaply transported lunar material for building radiation-shielded manned exploration spacecraft, O'Neil L-5 type space colonies, and Solar Powered Satellites. The space transportation concept being focused upon here is that of a specific form of transportation that is actually powered by the transport process in one direction, that from the lunar surface to a point dominated by the Earth's gravitational field about 5/6 the way up the Earth's gravitational well.

A tensile structure extends from L-1 (the balance point between Earth and Moon) both toward the Moon and the Earth; the lunar side anchors on the Moon's surface while the earthside dangles its weight far enough into the Earth's gravitational field to hold the lunar side up. The tensile structure is made of lunar fiberglass of constant-stress cross-section, and is robot-built by gradually increasing the girth of an emplaced seed filament. When functionally completed, energy transfers between payload mass falling down the earth side of the structure is coupled over to lift more payload mass up the lunar side of the structure via space-radiation-cooled superconductors on a magnetic-levitation track attached along the length of the structure. Payload mass is coupled to the maglev track via tractor motor-generators.

(The basics of this concept are on file with NASA, which I submitted for safekeeping early in 1972. In retrospect, it would have been a useful follow-up to the Apollo lunar landings, using the spare Saturn V launch vehicle to emplace the "seed" cable and soft-land the initial robot glass factory at the seed's lunar terminal. It might now be useful to revive this project as an international project utilizing the Soviet "Energia" booster to replace the now unavailable Saturn V booster. And here would be a worthy challenge for developing techniques for productive mutually benificial processes for human international interaction. Perhaps holistic concepts would be invaluable here, such as those of Organizational Psychosynthesis.)The Earth's physical makeup has so many incredible coincidences that are needed for life to exist upon it, and The Earth's moon seems an extension of those coincidences in the possible extension of Earthlife into space. The Lunar tides of earth's oceans upon her beaches has stirred tidal life onto land from the sea; now the fact that the Moon always has the same face turned toward the

Earth, and its relatively large mass near the Earth, show promise of a major stepping-stone for the extension of Earthlife into space. And the Lunar terrain is a potential source for raw materials for building space colony structures, closed-ecology very-large-spacecraft for exploration/colonization beyond the Earth-Moon system, and for exotic construction materials for use here on Earth such as foamed-nickel-iron-steel.

Space transport systems are necessary to transfer material and energy from where it is now, over to where it will be needed. Theoretically there are alternatives to the traditional reaction engine propelled vehicles which use energy stored in propellants. The energy differentials in space are another source of transportation energy.

Picture the Earth and Moon as being two adjacent depressions in a gravitational field. The Earth's depression is much deeper than that of the Moon's, so it is imaginable that material might be "siphoned" from the shallower depression into the deeper one. Basically this means that energy given up by payload mass falling down Earth's gravitational well is used to perform the work of lifting up more payload mass from the Moon up toward the Earth, thus forming a regenerative energy loop, self-sustaining, as is a siphon, so long as the output end's at a lower gravitational energy level than is the input end. Could an electromechanical analogy of a siphon be constructed to move raw materials from the Lunar surface over to a somewhat deeper level in the adjacent Earth's gravitational well, using the energy differential itself to power the process?

The work involved in getting out of the Moon's gravitational well to L-1 is only about 800 watt-hours per kilogram; and going from L-1 to Earth requires each

kilogram to give up about 16,000 watt-hours of energy, so there is plenty of energy to tap off for use in lifting mass up from the Moon to L-1. Of course, most of the 16.5 Kw Hr/Kg must be dissipated in the atmospheric entry process after the payload leaves the end of the end of the "siphon". With the end of the siphon-like electromechanical transport system extending deeper into Earth's gravitational well, surplus energy is produced which could be used to lift some of the payload up only to L-1, and leave from there with relative ease toward other parts of space near the Earth-Moon system. L-4, L-5, Mars and the asteroid belt, here we come!

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(Digression:But the reality was that NASA was at that time starving for funds just for the Space Shuttle project

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CALCULATIONS TO SHOW THAT FIBERGLASS, MADE IN A VACUUM,SHAPED INTO A CONSTANT-CROSSECTION TENSILE STRUCTURE, ISSTRONG ENOUGH FOR THIS TASK:

Note that at the time this concept was completed as a personal hobby activity, my only calculating tools were a slide rule and pen and paper. Believing that all I had to do was to show that an abundant material was capable for use in constructing the major portion of the mooncable, and then others with adequate computers would eagerly fill in the refinements, I set out set out to the disagreeable task of figuring out how to calculate

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Now m/R is the mass of a length of one radius, and making the area equal to 1 square inch to make the results in engineering terms,

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where S = stress at top pf the section = 2.5 E5 lbf/in2

Fl = attached load (bottom weight + conductor etc)

A = cross-sectional area of cable section

Expanded, this equation becomes

S = ((A*d*R*integral 1/r^2 dR)+Fl)/A

Solving for Area A:

A = Fl/(S-d*R*integral 1/r^2 dR

The force at the secion top then is

F = A*S = (Fl*S)/(S-d*R*integral 1/r^2 dR, or

Fn+1 = (Fn*S)/(S-d*R*(1/6)*g integral 1/r^2 dR

The force, F, then becomes part of the attached load, Fl, of the next cable section above it.

To make an example Mooncable calculation, some values will be somewhat arbitrarily assigned:

maximum upward pull on the Moon's surface by the cable and its loads is to be 35,000 lbf

superconducting maglev track will be equal in mass to two #12 copper wires, resulting in a mass of 2.2 E5 lbm per lunar radius.

the maximum force due to the live load will be 1 E4 lbf

This would be something less than 6 E4 lbm on the lunar surface; it is a dynamic load.

r2=Number of lunar radii reached at the top of the section

integral=avg acceleration along the section, in gees, g

fl=force at top end of section, in pounds, lbf

sectnarea= area of cable cross-section, in square inches

A home computer program for calculating this follows. As it only calculates from the Lunar surface out to 10000 lunar radii, ignoring the influence of the Earth, orbital velocity, or that of the Sun, it's purpose here is only to show that space-rated glass fiber is indeed strong enough for this task. And the lunar surface has an abundance of glass!

9000REM mooncable project cable calc, lunar influence

only,88I08 JEDCline

9010REM data list of radii

9020DATA 1.1,1.2,1.3,1.4,1.5,1.7,1.9,2.2,2.4,2.7,3

9030DATA 3.3,3.6,4.0,4.5,5.0,6,7,9,12,17,25,10000

9060 condrad=22000:REM conductors mass per lunar radius

length in lbm

9061REM condrad= conductor wt per lunar radius

9065REM conductor's weight=(2.2E5

lbm/radius)*acceleration integral for section

9070 stress=250000:REM stress in lbf/in2, max

working

stress in glass fiber made and used in vacuum

9075 fl=35000:REM lbf pull on lunar surface, includes 2.5E4

lbf bias pull plus 1E4 live load

9080 density=.083:REM density of glass in lbm/in3

9090 r1=68500000:REM radius of Moon in inches

9100 r0=1

9150? "calc# radii accel. intgrl top force area"

9200FOR calc=1 TO 23

9210READ r2

9220 integral=(1/6)*((1/r0)-(1/r2))

9221REM accel. integral across change in radius from

center of Moon

9250 force=((fl+(condrad*integral))*stress)/(stress-

(density*r1*integral))

9270 sectnarea=force/stress:REM cross-sectional area atop

section

9300? calc, r2, integral, force, sectnarea

9330 fl=force:REM becomes bottom load for next higher

section

9350 r0=r2:REM top of section becomes bottom of next higher

section

9360NEXT calc

9400END

radii	integrl	fl	sectnarea
lunar	g	lbf	inches^2
1.0		3.5E4	1.4E-1
1.1	1.52E-2	5.39E4	2.16E-1
1.2	1.26E-2	7.60E4	3.04E-1
1.3	1.07E-2	1.01E5	4.03E-1
1.4	9.16E-3	1.27E5	5.10E-1
1.5	7.93E-3	1.56E5	6.23E-1
1.7	1.31E-2	2.22E5	8.88E-1
1.9	1.03E-2	2.90E5	1.16
2.2	1.20E-2	3.99E5	1.60
2.4	6.31E-3	4.66E5	1.87
2.7	7.71E-3	5.66E5	2.26
3.0	6.17E-3	6.59E5	2.63
3.3	5.05E-3	7.44E5	2.98
3.6	4.21E-3	8.23E5	3.29
4.0	4.63E-3	9.20E5	3.68
4.5	4.63E-3	1.03E6	4.11
5.0	3.70E-3	1.12E6	4.49
6.0	5.56E-3	1.29E6	5.14

7.0	3.97E-3	1.41E6	5.65
9.0	5.29E-3	1.61E6	6.42
12	4.63E-3	1.80E6	7.18
17	4.08E-3	1.98E6	7.92
25	3.14E-3	2.13E6	8.53
1E4	6.65E-3	2.51E6	10.05

Dividing the cable up into 23 sections, summing the forces atop each section, reaches a value of 10 square inches at10000 radii, a realistic number. This shows that fiberglass cable does indeed have an adequate strength/mass ratio to do the job. Since the calculations were "outside approximations" the area would be less than this figure;also the attraction of the Earth on the cable, and the centrifugal orbital force on the cable would affect the full parameter calculations. For example, the mooncable would reach a maximum thickness where it passes through the balance point, L-1, and thereafter decreases in girth as it extends in the direction of Earth.

Note that when engineering something, the accuracy of calculations is directly important. But during the formative stages of a concept, utilizing the conceptual synthesis abilities of the right-hemisphere of the brain, accuracy of calculations is only conditionally important.

When the Mooncable calculations were originally done, plotting the curve of the cross-sectional area vs. distance from the Moon showed obvious calculation error; yet since the direction of error was to indicate that it would require even more glass crosssectional area that would in reality be needed, the weeks of tedious slide rule calculations were not repeated. The goal was reached anyway, it was thought, since all that was needed to be proven was that glass fiber was indeed strong enough to support a structure extending from the Lunar surface up through L-1 and on 1/6 the way into

Earth's gravitational well. Others with IBM 360 computers, or even with the new HP-35 pocket calculators, could more easily and accurately refine the calculations...

This concept proposes an energy balancing mechanism between descending payload mass and lifted payload mass, primarily useful for transporting huge quantities of lunar materials for Earth markets and for construction in the Earth-Moon system. The payloads destined for Earth Markets is cast into foamed material gliders for the atmospheric portion of the trip. It would function in the unique gravitational geometry existing in the gravitational saddle between Earth and her Moon. It would use a combination of adaptations of contemporary magnetic-levitation rail transit technology.

Calculations have been presented here to show that an abundant material on the lunar surface is sufficiently strong enough to support a fiberglass Mooncable out to infinity, and thus surely strong enough for the lesser task of reaching a maximum stress at the balance point, L-1.

The specific concept presented here is intended primarily for bringing Lunar and null-g vacuum environment commercial products to Earth at potentially very low expense on along-term, high-mass payload, continuous operation basis. It should also be useable to supply the materials for constructing powersats (SPS), and the help supply materials for building colonies at L-4 & L-5 and large manned spacecraft for the further exploration of space.

The general concept presented here is intended to arouse the readers' creative imagination toward seeking alternative paths for bringing mankind and other Earthlife into nearby extra-terrestrial space.

In retrospect, this would have been an ideal follow-on to the Apollo program, which was winding down at the time the Mooncable Project was proposed (informally) to NASA. It would have utilized the two extra Saturn V launch vehicles already built, provided stimulus to reactivate the Saturn V assembly line, provide just enough challenge to technology to make it interesting, and would have provided construction materials in space by the time the space shuttle became operational. The potential for providing competitive massive supplies of building materials for sale even here on Earth...is an unheard-of thought even now in space activist circles.

What went wrong? Why didn't the Mooncable Project get accepted? Perhaps we can learn from the mistakes of the past.... Perhaps it was that NASA was too sunk in the gloom of seeing its own finances so cut back to see, in the Mooncable Project, potentials for utilizing lunar resources, the chance to rekindle America's excitement for the space adventure. Perhaps it was that NASA, functioning under its integrity charter of not supporting potentially profit-making space enterprises, had no understanding of the author's extremely naive concept of the politics involved and non-existent salesmanship skills. The author believed that "Invent a better mousetrap and the world will beat a path to your door!"

Now there are more appropriate concepts for the leading edge of space efforts. The US no longer has the ability to produce Saturn V launch vehicles, and is unlikely to form an alliance with the Soviets to utilize their new "Energya" equivalent booster. More importantly, there have been several even more exciting space transportation concepts conceived since the Mooncable Project's time: concepts for Earth-to-

space transportation, of immense proportions and implications, utilizing maglev support structures that utilize forms of stored energy for support, bypassing the weakness of the inadequate materials strength for Earth-surface-to space centrifugally-supported structures. For example the concepts (with rather flippant names) known as "Starbridge" (by R. Hyde) and "Texas and Universe Railroad" (Earl Smith), The Launch Loop” (K. Lofstrom). And there are others. These concepts seem largely unknown to the public at present, although they have been available to the public, and NASA, at least since 1984. I suspect that their authors are also amazed (as was the Mooncable concept's author was in 1972) at public apathy toward the incredible futures for humanity that the concepts make possible. The huge payloads moveable by these megaprojects pave the way for true massive space colonization, in settings that are as Earthlike as possible, in this generation.

What can be done now? Perhaps the public, and even NASA, needs to have the imagination provided for them in clear detail... instead of assuming auto-evocation of the possibilities of each concept by each reader.

James Edward David Cline (GEnie J.E.D.CLINE1 or J.CLINE2)
Van Nuys, CA September 9, 1988

This paper and associated slides was prepared by the author for the SESI 2007 space conference, and sent for the conference; but ironically, the author's participation was prevented by transportation failures on the ground; and the technical paper and PowerPoint presentation vanished from the conference. As usual, it was highly controversial, not adequately in line with the tether Earth Space Elevator theme of the conference.

Long Range Electromechanical Power Transmission Along Space Transportation Structures

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Abstract. Although the transmission of energy across long distances is generally considered the domain of electrical conductors and electromagnetic radiation beams, in the field of very large space transportation structures it may be worthwhile to re-visit electromechanical energy transmission distribution means. Some such means include pulley-terminated tether loop space elevator as an efficient bucket-lifted conveyor belt system; fountain-like support of weight by use of continuous loop mass stream flow; wave motion power transmission along an anchored centrifugally supported tether; and delivery of electromagnetically coupled kinetic lift energy by means of high velocity electric motor armature segments sliding along embedded maglev tracks. Such electromechanical distribution of energy may be interestingly applied to the lifting of payload mass up along large space transportation structures, or to form temporary lifting structures from ground to space.

1. Context

An expanding and long term viable technology based civilization which is having a major impact on the world ecosystem which supports the civilization and is reaching limits of adequate economical energy resources, needs to reach for more resources of energy, materials, recycling systems, and room to grow. Preparing technologies which may be adequate in capacity and efficiency to do the transportation part of these tasks in the near term, is prudent for responsible leadership. The decisions as to whether or not to utilize the prepared technologies remains, of course, in the hands of the social systems active at the time and in the past.

Space resources in high earth orbit and beyond have the potential for greatly assisting civilization's long term viability and expandability. These resources include plenty of room to build within, plenty of hard vacuum to process materials in, microgravity processing and living environment variable up to 1-g by centrifugal action, and of course abundant 24/7 raw solar energy unimpeded by day-night cycles nor latitude nor cloud cover. Sufficiently adequate capacity and efficiency transportation between the earth surface and orbit is required for the utilization of space resources in quantities able to make significant impact on fulfilling civilization's requirements. Since existing types of space access through use of chemically fueled reaction engine vehicles expend most of their energy just in lifting the fuel and its tankage, their energy efficiency is extraordinarily poor in comparison to the actual energy added to payload mass by virtue of its being moved from the earth surface up into Geostationary Earth Orbit, which is only 15.72 kWh per kg, costing only $1.58 per kg lifted to GEO at an energy cost of $0.10 per kWh. Surely there are ways to make huge improvements in energy efficiency for transportation to and from GEO to ground. Scalable electrically operated transportation structures extending from ground to GEO seem ideally capable of providing this transportation function that could enable civilization's large scale near-future access to space resources.

Such transportation structures as currently visualized include anchored tether structures which are supported by the outward centrifugal force of mass beyond GEO swung around by the daily rotation of the Earth, which are highly dependent on adequate strength to mass ratio tether material availability; and structures which are not dependent on extreme materials strength, but instead on the continuous circulation of kinetic energy within itself expressing as outward centrifugal force which balances the weight of the track and hard vacuum environment maintenance tubing which constrains the path of the high velocity flowing mass

streams as they loop around the planet continuously within the structure.

The movement of payload up and down such structures still requires adequate energy sources of lift energy delivered to the lifting vehicles traveling the structures between ground and high earth orbit. Carrying along the fuel or batteries required to provide the climb up the structure reduce the efficiency of such transportation systems, somewhat as does reaction engine propulsion systems. Potential mechanisms for delivering the transportation energy to the vehicles traveling such structures include energy which is transmitted by the structure itself, and these are explored in this paper.

Radii section endpoints, in Earth radii	Radius to base of section, in meters	Gravitational – centripetal net acceleration in m/s^2	Length of tether section, in meters	Net acceleration times tether length times density, in Pascals	Sum of stresses from Earth surface to top of tether section, in Pascals
1.0 to 1.2	6.37e6	9.83 – 0.034 = 9.80	0.2 R = 1.27e6	1300 x 9.80 x 1.27e6 = 1.62e10	1.62e10
1.2 to 1.5	7.64e6	6.83 – 0.04 = 6.79	0.3 R = 1.91e6	1.69e10	3.31e10
1.5 to 2.0	9.56e6	4.36 – 0.051 = 4.31	0.5 R = 3.18e6	1.78e10	5.09e10
2.0 to 2.5	1.27e7	2.47 – 0.067 = 2.40	0.5 R = 3.18e6	9.92e9	6.08e10
2.5 to 3.0	1.59e7	1.58 – 0.084 = 1.50	0.5 R = 3.18e6	6.6e9	6.74e10
3.0 to 3.5	1.91e7	1.09 – 0.101 = 0.99	0.5 R = 3.18e6	4.09e9	7.15e10
3.5 to 4.0	2.23e7	0.802 – 0.118 = 0.68	0.5 R = 3.18e6	2.81e9	7.43e10
4.0 to 4.5	2.55e7	0.613 – 0.135 = 0.48	0.5 R = 3.18e6	1.98e9	7.63e10
4.5 to 5.0	2.87e7	0.484 – 0.152 = 0.33	0.5 R = 3.18e6	1.36e9	7.76e10
5.0 to 6.0	3.18e7	0.394 – 0.168 = 0.226	1.0 R = 6.37e6	1.87e9	7.95e10
6.0 to 6.6 GEO	3.82e7	0.273 – 0.202 = 0.071	0.6 R = 3.82e6	3.53e8	1300 x 6.146e7 = 7.99e10

Table 1. Approximating non-tapered space elevator tether material stress requirement

Although most tether space elevators assume a tether material inadequate for a non-tapered tether, the forms of space elevators become quite different when a tether material is strong enough to support use of a non-tapered tether structure. To error on the high side, the approximation here uses a tether divided up

into 11 sections, and each section is assumed to have a constant acceleration that is equal to that found at the base of each section due to gravity and centripetal acceleration's sum. The density of the material is assumed to be 1300 kg/m^3. The stress on the tether material at GEO is found to be 80 GPa in the table below. Therefore, a tether material strength that is above this threshold of 80 GPa is assumed in the elevator forms in this paper.

2. Potential means of distributing lift energy along a space access transportation structures explored here are:

A. Pulley-terminated tether loop space elevator as an efficient bucket-lifted conveyor belt system, requiring tether material of around 80 GPa or greater

B. Fountain-like support of weight by use of continuous loop mass stream flow

C. Wave motion power transmission along an anchored centrifugally supported tether

D. Delivery of electromagnetically coupled kinetic lift energy by means of high velocity electric motor armature segments sliding along embedded maglev tracks

In general, payload lift energy could be tapped from the upward moving part of each of these energy flows along the way to be used to lift payload carrying vehicles up the structure. This would deliver the energy to the captive vehicles needed to lift the payload, instead of needing to lift an energy source, or track the vehicles with laser beams, to provide lift energy to the cargo vehicles.

Let us now look more closely at each of these means of distributing lift energy along very long space transportation structures.

3. Pulley-terminated tether loop space elevator as an efficient bucket-lifted conveyor belt system.

This is perhaps the simplest of the systems. It requires a tether working stress material sufficient for constant cross-section construction, of around 80 GPa or more strength to mass ratio. It is slow but highly efficient, so in initial form is for lifting radiation resistant payload materials, and would be powered either directly from

solar power panels in GEO, or by electric power on the earth surface. A lower payload transfer rate variation would use a shielded transfer cargo container.

Except for the anchored tether part, it resembles ancient conveyor belt loop bucket lift systems. However, it requires the greatest strength to mass ratio tether material of any of the systems; around 80GPa. The tether needs to be in the form of not one but two belts that are connected together at the pulley ends to form a continuous closed loop. The tether material also needs to periodically endure bending around the pulley's radius. However, the material does not have to endure the friction of climbers' compression rollers moving up and down along its surface, as would some other forms of travel along a tether. The pulleys would be at each end of the tether, one at the earth surface terminal, and the other far out beyond GEO near the end counterweight. Both points are low load points, minimizing bearing stresses. At GEO, where an optimum space platform complex could be built, the belt tether could be driven by an electric motor powered by photovoltaics, providing the lift energy for the transportation system from the Sun. This configuration also has the advantage that the weight of the descending vehicles would return most of their energy received in their lift to GEO. Figure 1 shows a simplified diagram of such a mechanism.

One of the characteristics of such a payload lift system is the relative slowness of travel along the path between ground and high earth orbit, as the speed of the captive vehicles is identical to the speed of the tether ribbon on which they are attached. The speed of the tether is limited by the stresses endurable by the tether as they suddenly are turned around the pulleys, and by the speed which is endurable by the drive wheels in GEO. Thus this technique would by extremely efficient for lift of materials to GEO, but also relatively slow. Also, the captive vehicles have to get a running start to match the speed of the tether when they climb onto the tether, and when are approaching the target altitude they need to release from the tether and brake to the standing velocity at that location, such as at GEO; conceivably momentum-transfer exchange could be given for payload returning toward the earth surface could provide this function. Much of the attachment and release infrastructure that is on the tether is a static load, balanced in both upward and downward directions, but does represent extra tensile stress on the tether ribbon material.

Although the amount of solar-sourced electric power supplied by this technique is small, using the tether to drive an electric generator at the earth surface pulley site does represent a way to transfer solar-sourced electrical energy to the earth surface without use of radiant beamed energy Passively shielded lift for personnel and other radiation-intolerant payload, is provided by a vari-

ation on this method. It would use a relatively massive cargo lift container attached to the tether ribbon, which utilizes several feet thickness of sawdust-reinforced water ice as a passively shielding shell. Water ice is chosen for the shielding mass for minimizing environmental damage in case the container falls to earth, disintegrating in the atmosphere. The significant added shielding mass would reduce the overall throughput of payload, and/or require more tether strength. It would also require bi-directional movement of the tether loop, along with starting and stopping the tether belt when the shielded cargo container arrives at ground or GEO terminals. However, this would eliminate the need for the running start mechanisms on the ground, and momentum transfer mechanisms at the GEO terminal..

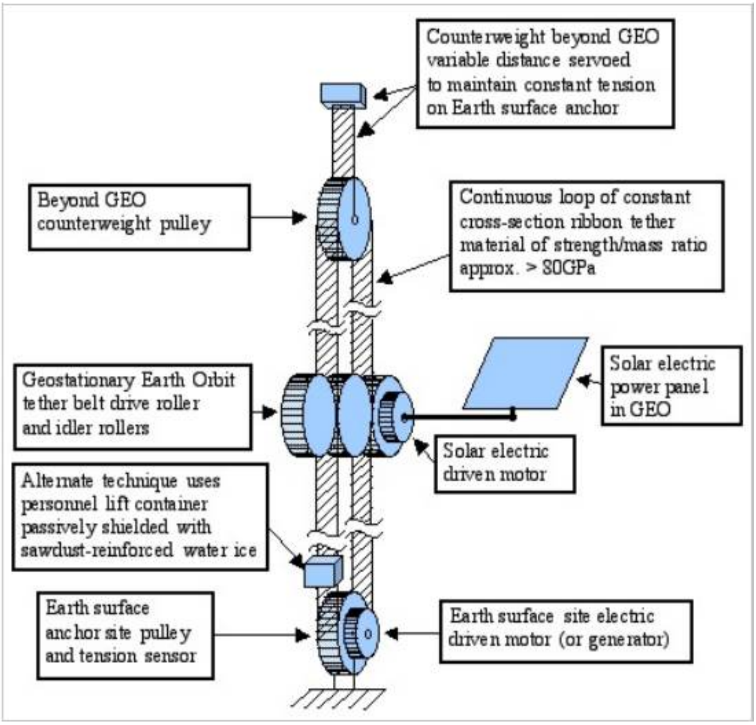


Figure 1. Schematic of a pulley-terminated tether loop space elevator as an efficient bucket-lifted conveyor belt transportation space elevator structure

Note that the use of sawdust-reinforced water ice as passive shielding mass becomes feasible due to the continuous running high efficiency transportation potential of some of the transportation access lifting structures explored in this paper, and could be extensively to shield occupied areas of structures built in GEO, protecting from solar storms and cosmic radiation, as well as used for crew lift slowly through the radiation belts between LEO and GEO.

If more than one of this kind of tether space elevator is used, one of them could be for radiation-tolerant material payloads at the slower lift speed, but higher semi-continuous throughput, and another could be for the lower throughput transfer of radiation-sensitive payloads such as personnel and biological materials.

4. Fountain-like support of weight by use of continuous loop mass stream flow for long range electromechanical power transmission along space transportation structures

This concept is analogous to a fountain of water or air, such as once used in department store vacuum cleaner displays, where a vertical air stream supported a ball seemingly floating in mid-air; it also draws on Rod Hyde's “Starbridge” vertical tower concept. The use of continuous streams of projectiles in the form of electric motor armature segments launched upward to be intercepted at a higher platform and then bounced back to the lower site, maintaining a continuous flow of mass in both directions, the catching and reverse thrusting of the mass of the projectiles supports or lifts the upper platform. Additionally, the upward-moving mass stream could have some of its kinetic energy electrodynamically tapped off to lift vehicles along the path, as well as also to similarly provide static support to weight that is unmoving, such as that of air-excluding tubing and maglev rails. The earth surface site needs to have strong electromagnetic means to turn the returning armature mass stream around while also restoring the kinetic energy that was used during the process.

This concept would consume continuous energy in the process of supporting air-excluding tubing in the atmospheric portion, as well as in the balancing of platform mass somewhere above the ground. It has the advantage that, once air-excluding tubing was extended to above the atmosphere, and using adjustable angle tubing, the height of the supported platform could be raised or lowered by the raising of the upward velocity of the supportive armature mass streams.

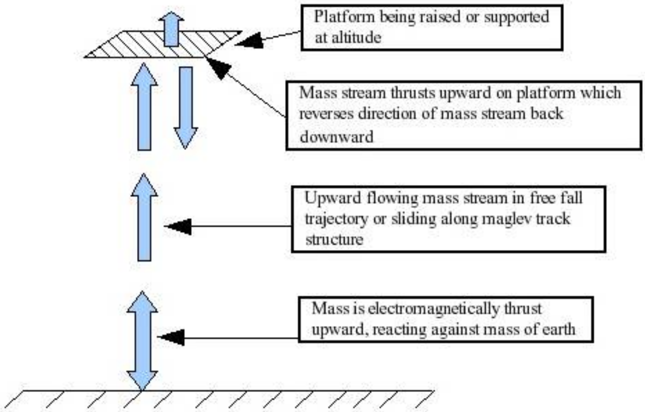


Figure 2. Basic principle of support of weight by use of continuous loop mass stream flow

Conceivably this principle could be used to form temporary lifting structures from ground to space, or to provide support between a lower orbiting mass and a higher altitude smaller mass that is moving at the same angular velocity as the lower mass and held stationary or being lifted higher thereby.

5. Wave motion power transmission along an anchored centrifugally supported tether

Use of a single-band tether itself as a transmission line for energy, brings the thoughts of electromechanical vibration of one end of the tether and having the mechanical wave motion propagate along the structure; and of using conductivity along a tether as a waveguide for electromagnetic wave propagation. These methods of delivering energy along a tether are highly dependent on the characteristics of the tether material chosen.

Potential techniques requiring electrical conductivity of the tether material would depend on the carbon nanotube fibers being well woven together before being matrix bound by a non-conductive encapsulating material. The resistivity of carbon nanotubes would control this aspect.

If the resistivity of a tether extending far beyond GEO is high, as would be expected at this point, then the possibility of us-

ing extremely high voltages might be considered, using two widely spaced tethers so as to provide a continuous loop for the current. The voltage drop across any small segment of the tether could be small enough as to be fairly safe for occupants riding a vehicle up and down such tethers. Re-examination of Tesla's concepts might provide some additional approaches to this technique. This possibly could provide end-to-end electrical energy delivery; and with sufficiently spaced roller electrical contactors of a vehicle so as to provide enough voltage drop potential along the tether to power on-board electrical lift motors.

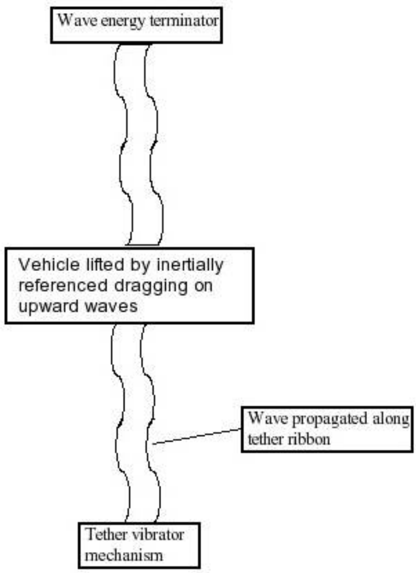


Figure 3. Principle of lift energy transfer along tether by wave transmission along tether itself

Rolling a band or ribbon cross-section tether into a circular or rectangular cross-section tube might be explored as a waveguide for electromagnetic wave transmission along the enclosed tube thus formed, for end to end power transmission. Again, the efficiency of such a method would be highly dependent on the resistivity of the tether material. Maintaining a constant tubular cross-section along a constant-stress tapered tether would eliminate

many construction technique possibilities, and seems difficult when utilizing scalable construction techniques, unless the conducting channel part of the tether is added as a step after a tapered cross-section scaled up tether of sufficient strength were previously built. If constant cross-section tether material, of about 80GPa were used, the overall tether could be formed into a RF waveguide after scaled up to sufficient girth so as to provide the internal volume for the RF wavelength chosen for electrical power transmission.

The need to deliver lift energy to vehicles climbing up and down a tether means energy needs to be tapped off by the vehicle wherever it is along the tether. Mechanical wave motion seems better suited for the task of delivering useful energy all along the tether. Wave modes that are lateral, as in a vibrating string, or longitudinal tension waves, would require a vehicle to have an overall length of one or more wavelength of the tether wave motion, and probably use the inertial mass of the captive spacecraft as a reference for extracting some of the energy contained in the passing wave motion of the tether. To avoid standing waves along the tether, all remaining wave energy would be needed to be extracted at the far terminal, absorbed into a load of the same characteristic impedance as the tether. The efficiency of mechanical wave motion along such a tether is highly dependent on the modulus of elasticity and damping factor of the stretched material. If the tether material is of sufficiently strong material as to have a constant cross-section, even then the tension along the tether would vary widely and thus similarly the propagation characteristics would vary. Such a tether would, however, be amenable to scaling construction techniques, and be able to deliver lift energy all during construction.

6. Delivery of electromagnetically coupled kinetic lift energy by means of high velocity electric motor armature segments sliding along embedded tracks

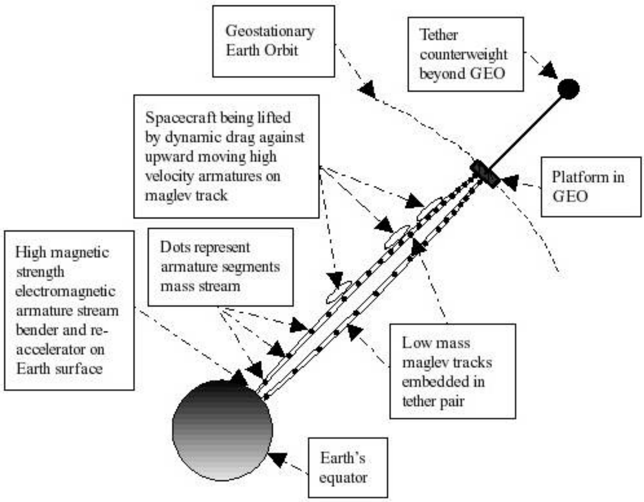


Figure 4. Delivery of lift energy to captive spacecraft by sliding armatures along linear track

This means of energy delivery to captive spacecraft vehicles could be applied to both the linear anchored tether configuration, and to the planet-encircling loop structure configuration. Such
high velocity armatures, operating at tens of km per second velocities, sliding along either a linear or loop structure, would yield up a small portion of their momentum to the vehicles they pass, through electromagnetic inductive braking against the rising direction armature mass streams.

Such armature mass streams flowing along linear long transportation structures would need significantly less maglev track field strength than would a loop structure, as they would not need to do anything except to deliver some of their momentum to vehicles traveling the structure while lightly following the track. But there would need to be relatively enormous maglev field strength at the ends of the structure to turn around the armature segments. The re-accelerator would presumably be part of such a turn around structure at the power input end of the transportation structure. However, such upward lift energy could also be coupled over to the structure itself so as to augment support for the structure's

weight, reducing the tensile strength needed for the tether material; but this would involve a lot of power lost just to support the structure. Might be useful temporarily during elevator construction, however.

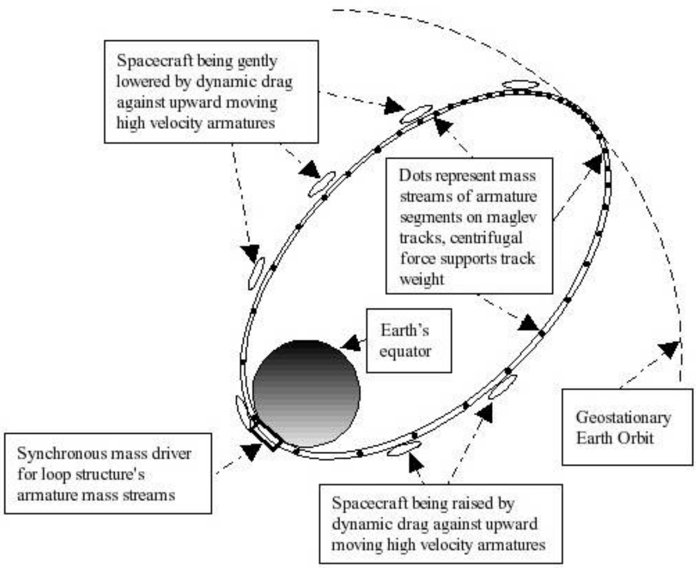


Figure 5. Delivery of lift energy to captive spacecraft by sliding armatures along curved track

The planetary loop form of structure involves use of the planetary gravitational field to bend the high velocity mass stream around to form continuous closed loops in which to travel up and down from the earth surface to high earth orbit. Thus there is no need for powerful turn around magnetic fields at the transportation terminals. However, since the high velocity armature segments are not only functioning to deliver lift energy all along the structure to lift captive spacecraft along the structure between ground and orbit, but also to support the weight of the track and tubing structure through their supra-orbital-velocity outward centrifugal force exerted against the path-defining planet-encircling maglev track so as to balance the weight of the track structure with its live loads, the strength of the maglev track field has to be greater than that of the linear form of structure.

Since the weight of the track structure is borne by the centrifugal force of the armature segments as they are bent around the planet, the structures can be made of common materials instead of requiring the extreme strength to mass ratio materials needed for linear tether space elevators.

In either case, vehicles conceivably could be lifted up along, and gently lowered, by lightly dragging against the high velocity armature mass streams racing past them in the upward direction. This would distribute the lift force all along the long transportation structure to wherever the point of need for captive vehicular lift energy would be as they travel along.

As these captive vehicles could slide along their own maglev inductive tracks, their velocity through the radiation belts make heavy shielding of crew carrying vehicles much less necessary.

In the case of the linear tether structure, the elements of the maglev track would need to be attached to, or embedded within, the tether material. The tether would need to bear the weight of this maglev material. As the stresses to the maglev field are minimal in the linear configuration, the mass of such track material would likewise be minimal.

The form of the maglev track needs significant research, as it would be quite different from existing maglev track systems, such as those used on massive relatively slow maglev railroad trains. The space transportation maglev track would need to be inductively energized by the passing armature segments, for one thing. This becomes conceivable due to the fact that the armatures are traveling at tens of kilometers per second in a hard vacuum, and inductive coupling goes up as the cube of the velocity differential. This maglev track design for the armature segments ought to be an interesting project, since it would be easier to test it in orbit where there is abundant hard vacuum and plenty of room to build the track in the form of a huge loop. However, on the ground where it needs to be at least initially developed, it would require many km of hard vacuum enclosing tubing as the loop, and much greater maglev track field strength so as to bend their path into a closed loop. For testing the linear tether track, a horizontal test facility could employ the same high field strength turn around magnetic fields as would be used for the actual tether armature turn-around re-accelerators, so the whole system could be tested together to a large extent, to characterize the parameters. Note that such a horizontal test facility would also provide experience needed for the "fountain-like" lift technique mentioned above.

7. Conclusions

Although electromechanical means of energy transmission may seem a giant step backwards in the present day, re-visiting the subject while including contemporary technology may provide uniquely well suited means for captive vehicular lift or support of mass across large distances in the space environment, as well as non-beamed energy transfer between space and the Earth surface, to provide transportation systems between the Earth surface and high earth orbit that are sufficiently efficient and of ample average lift throughput to be able to support the enormous construction projects needed in high earth orbit so as to sustain a vigorous civilization; and for electrically lifted linking to spaceports in GEO for very large scale ventures further into the solar system.

References

Cline, J.E. David, “Treehouse Haven”, Meditation Magazine, 1989
Cline, James E. D. (JEDCLINE1), “LONGTRANS 2”, GEnie Space Library file #927, 1989
(www.kestsgeo.com/pages/geniefiles/g927.html)
Cline, J. E. D. “A Potential Application of General Systems Theory: KESTS: A Unique Transportation Technology Concept & Implications” Presentation to Los Angeles Chapter of ISSS, November 9, 1994. (http://www.kestsgeo.com/pages/issskests.html)
Cline, James E. D. “Kinetically Strengthened Transportation Structures.” Space 2000 Conference Proceedings, ASCE, 2000, 396-402.
Cline, James E. D. “Kinetically Supported Bridge Vehicle Lift To GEO.” Space 2002 Robotics 2002 Conference Proceedings, ASCE, 2002, 8-21.
Cline, James E. D. “Comments and alternatives, by Jim Cline, regarding the anchored tether Space Elevator project proposed by Bradley Edwards...”, 2002,
www.kestsgeo.com/pages/cobetse.html
Cline, James E. D. “Energy Flow in Kinetically Strengthened Transportation Structure Systems to Space” Earth & Space 2004 Conference Proceedings, ASCE, 2004, 859-866.
Cline, James E. D. “Characteristics of Space Escalator Carousels vs. Space Elevators” Space Exploration 2005 Conference Proceedings, SESI, 2005, 355-364.
Hyde, Rod, “The Starbridge Concept” , L-5 Society lecture, Sunnyvale CA Sept. 23, 1984
Lofstrom, K.H., “The Launch Loop”, L-5 NEWS, 8-9, Aug. 1982
Smith, Earle, “The Texas and Universe Railroad”, L-5 NEWS, 9-11,1985

The following are the presentation slides prepared for this conference presentation:

Long Range Electromechanical Power Transmission Along Space Transportation Structures

James E. D. Cline

Although the transmission of energy across long distances is generally considered the domain of electrical conductors and electromagnetic radiation beams, in the field of very long space transportation structures it may be worthwhile to re-visit electromechanical energy transmission distribution means.

The form of delivery of transportation energy along a long transportation structure needs to be chosen in overall context with its application, such as the job of cleanly enabling a high technology worldwide civilization through adequate access to GEO space resources, all done carefully and quickly enough before our bourgeoning haphazard civilization can destroy itself.

A chosen transportation system has to be up to doing the overall job providing for civilization's near future needs: in more detail this overall transportation task contextually can include:

- Putting enough Solar Power Satellites into GEO to cleanly electrically power the energy hungry high tech civilization now rapidly expanding worldwide, saving petrochemicals
- Putting mass-spectrometer type total recycling plants into GEO to process the toxic materials produced by industry worldwide, and ability to lift those waste materials up for processing and bring the clean materials back down
- Building large scale spaceports in GEO and to lift the components for the immense spacecraft up to them for commerce to the Moon and other places in the Solar System
- Building a few Stanford Torus Space Settlements in GEO, along with enough sawdust reinforced water ice to provide their passive shielding into GEO for R&D of such cities

Transportation energy is one key to success: the actual energy given to payload by lifting it up from the ground and put into GEO is only 15.7 kWh/kg, $1.57 per kg at $0.10 per kWh

- Note that this is a little less than the energy given to achieve escape velocity, 17.4 kWh/kg
- But also using energy to support the payload while it is slowly traversing up the gravitational field in between, can add a huge amount to the total energy cost for the lift
- The delivery energy cost to GEO could be greatly reduced by using a transportation structure all along the way so as to support the payload while it is being lifted

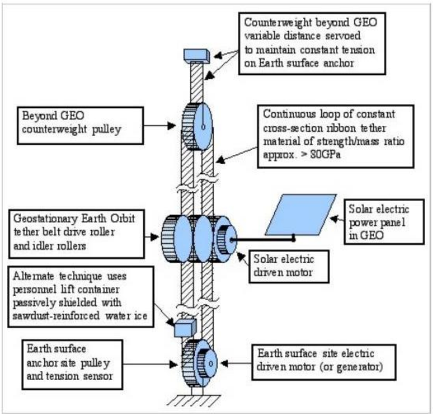
The transportation structure itself can be configured to distribute the transportation energy along itself to the payload all along the way

- Let's explore how perhaps payload can be lifted …
- by attaching to part of the structure that continuously circulates between the transportation terminals
- by tapping into the momentum of rapidly moving upward bound electric armature mass passing the payload carrying vehicles, overall a kind of synchronous electrical motor
- by higher velocity mass bouncing off its base like a fountain
- by tapping wave motion energy propagating along the structure

The means of support of a transportation structure control its shape and the options for distributing energy along the structure. Two ways to support a transportation structure bridging planetary surface and geosynchronous orbit include:

- By an anchored tether being swung around by the planet's daily rotation, supported by the centripetal force on the tethered mass beyond GEO
- By an eccentrically shaped hoop around the planet, its internal mass moving around sufficiently faster than orbital transfer velocity to generate distributed outward centripetal force to balance the weight of the non-rotating part of the hoop with its live loads

Payload can be lifted and lowered by attaching to part of a structure that continuously circulates between the transportation terminals



Radii section endpoints, in Earth radii	Radius to base of section, in meters	Gravitational – centripetal net acceleration in m/s^2	Length of tether section, in meters	Net acceleration times tether length times density, in Pascals	Sum of stresses from Earth surface to top of tether section, in Pascals
1.0 to 1.2	6.37e6	9.83 – 0.034 = 9.80	0.2 R = 1.27e6	1300 x 9.80 x 1.27e6 = 1.62e10	1.62e10
1.2 to 1.5	7.64e6	6.83 – 0.04 = 6.79	0.3 R = 1.91e6	1.69e10	3.31e10
1.5 to 2.0	9.56e6	4.36 – 0.051 = 4.31	0.5 R = 3.18e6	1.78e10	5.09e10
2.0 to 2.5	1.27e7	2.47 – 0.067 = 2.40	0.5 R = 3.18e6	9.92e9	6.08e10
2.5 to 3.0	1.59e7	1.58 – 0.084 = 1.50	0.5 R = 3.18e6	6.6e9	6.74e10
3.0 to 3.5	1.91e7	1.09 – 0.101 = 0.99	0.5 R = 3.18e6	4.09e9	7.15e10
3.5 to 4.0	2.23e7	0.802 – 0.118 = 0.68	0.5 R = 3.18e6	2.81e9	7.43e10
4.0 to 4.5	2.55e7	0.613 – 0.135 = 0.48	0.5 R = 3.18e6	1.98e9	7.63e10
4.5 to 5.0	2.87e7	0.484 – 0.152 = 0.33	0.5 R = 3.18e6	1.36e9	7.76e10
5.0 to 6.0	3.18e7	0.394 – 0.168 = 0.226	1.0 R = 6.37e6	1.87e9	7.95e10
6.0 to 6.6 GEO	3.82e7	0.273 – 0.202 = 0.071	0.6 R = 3.82e6	3.53e8	1300 x 6.146e7 = 7.99e10

Approximating non-tapered space elevator tether material stress requirement

A passively shielded lift version for personnel and other radiation-intolerant payload could use a relatively heavy cargo lift container attached to the tether ribbon, utilizing several feet thickness of sawdust-reinforced water ice

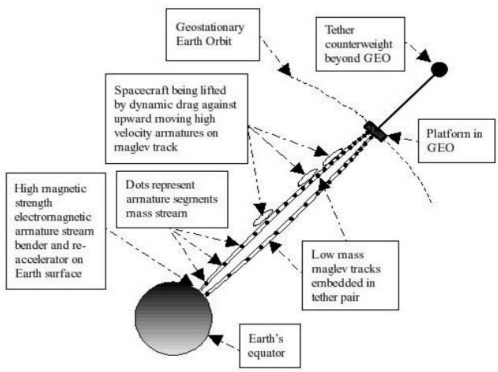
- This would minimize environmental damage in catastrophic case of the container falling into the atmosphere.
- The significant added shielding mass would reduce the overall throughput of payload.
- It would also require bi-directional movement of the tether loop, along with starting and stopping the tether belt when the shielded cargo container arrives at ground and GEO terminals.

Another basic way for distributing transportation energy along itself is by providing paths for high velocity circulating mass streams along the structure, that electromagnetically share part of their upward moving momentum to lift vehicles riding the structure.

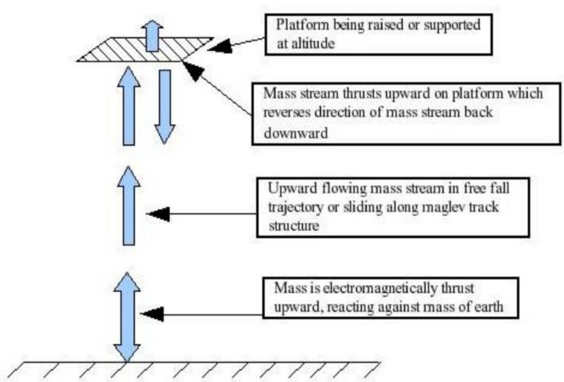
- Along linear anchored counterweight- supported tether structures.
- Along planetary loop structures, where circulating mass also uses its outward centrifugal force of the loop, to balance the weight of the stationary part of the structure.
- Along fountain type supportive or lifting structures.

Payload can be lifted by tapping into the momentum of rapidly moving upward bound mass passing the payload carrying vehicles along a linear tether structure

High velocity upward moving armatures inductively drag vehicles upward to space, or lower them gently back to earth

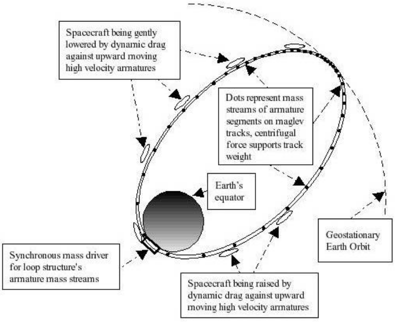


Schematic of fountain-like support or lift where upward high velocity mass bounces off vehicle, imparting upward reaction vehicle lift force



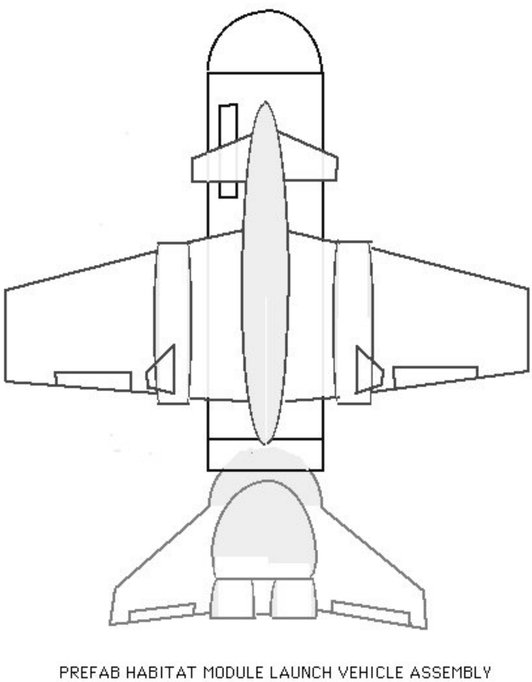
Payload can be lifted by tapping into the momentum of electric motor armature mass continuously moving at 10's of km/s along inductive maglev tracks embedded in the motor stator along a hoop structure around a planetary body

- Electric motor armatures distribute lift energy to vehicles
- Armatures distribute servoposition energy to the structure
- Armatures generate outward centripetal force to balance weight of structure and vehicles



Building the Low Earth Orbit Classical Wheel-type Space Station:

The adventure next drifts into the building of a version of the classical wheel-type Space Station in Low Earth Orbit, using a technique I had proposed, for building prefab modules of the wheel, assembled and testing on the ground for livability and systems integration, then since each wheel segment was designed to be used as its own fuel tank during launch, each segment module is launched by chemical rocket for teleoperated docking



PREFAB HABITAT MODULE LAUNCH VEHICLE ASSEMBLY

Dwn 1998 JEDC

into the mile-diameter spoked wheel configuration in LEO; all put together before the first human arrives at the space station, making it a low-cost, risk-free construction process; of course, all such projects have difficulties and politics involved and an example play out in the novel, "Building Up." The following are the major technical articles the author wrote on this subject, starting 20 years ago.

The Centristation Concept, early writings the author put in the Genie Spaceport Library

CENTRISTATION III
J. E. D. Cline Dec. 17, 1989

A pair of unmanned engine/control system flyback modules boost a segment of a centrifugal space habitat toroid into LEO; during launch, space station segment is serving as the fuel tank.

This document outlines a conceptual design that is squarely on the path to space colonization. A low-cost, safe centrifugal space station, with its launching system, that is worthy of the 1990's. See sketch. This very economical space station conceptual design perhaps can rekindle America's interest in the adventure of space, while providing a solid stepping-stone towards extending mankind's living resources beyond earthsurface. An adventurous, yet practical, Space Station Habitat.

Features:

--utilizes proven technologies.
--a low-cost, versatile, rotating centrifugal 1-gee large space station is created.
--a new class of launch vehicles is created, consisting of a pair of winged flyback modules containing only

engines and control systems ... the first flyback engine cluster module drops off prior to orbital insertion, and the second smaller single-engine-module returns after placement of the habitat-module in position in orbit; and an upper stage which is built both as a furnished space station habitat module, and also as the fuel tank during launch.

This Space Station Habitat design is a segmented toroid, for indefinitely long habitation, a precursor to an Island-One Stanford Torus space habitat. Each segment of the torus circumference is built to also function as the upper stage and fuel tank during launch. The reuseable engine(s) and control system return as stubby winged re-entry vehicles back to the launch pad site after finishing putting a segment of the toroid into LEO. (A pair of refurbishable strap-on boosters, perhaps of AMROC LOX/SRB form, could be used instead of the second flyback engine module).

--- PURPOSE AND ADVANTAGES ---

1. Economical, safe space station construction is achieved by building the toroidal habitat on the ground in nearly finished form; by shrinking the space shuttle orbiter to mere pair of unmanned engine/control system flyback stubby winged shapes; making each toroidal space station habitat segment into a fuel tank temporarily for the launch as the upper stage; and automatic docking of the modules to form the toroidal ring of dozens to hundreds of segments. The ring is then spun-up and ready for occupancy. The inhabiting workers reach the free-fall vacuum industrial environment by climbing through spokes to the toroidal ring's hub.

2. Centristation demonstrates space colonization, and quickly in the coming decade. As we know, large-scale

space colonization potentially can be an alternative to the crowding out of fellow lifeforms on the planet, consuming finite natural resources rapidly, and littering our home planet with enormous heaps of garbage and refuse.

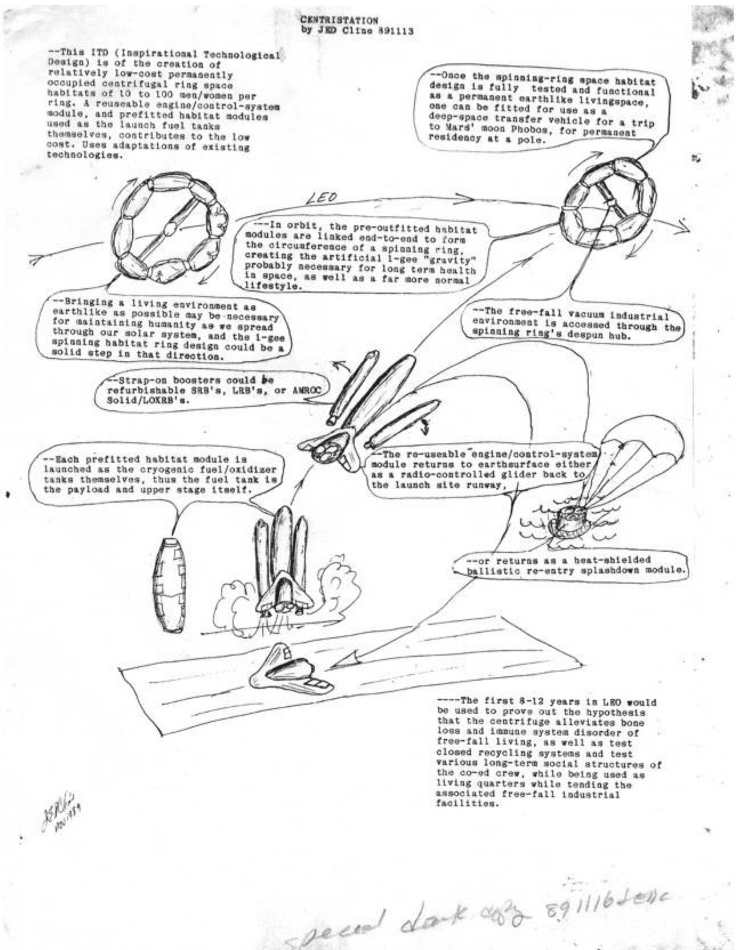
3. This project supplies the drama of space colonization started in the 1990's. Mankind needs daily drama in life just like food and shelter. Witness the lure of television shows and newspaper headlines. Life in space needs to encompass all the functions of being human, in addition to being interesting and sometimes adventurous. Life there needs to be shown to be capable of being very comfortable, safe, and supporting the mating and family-raising activities that humans normally need. The drama of achieving these in the vast room and resources of space can excite the imagination of humanity, supplying a new confidence in the future of humanity and of planet earth's ecology. And Centristation could be modified for relocation at Mars' moon Phobos, or be boosted to GEO when KESTS (Kinetic-Energy-Supported Transportation Structures) are operational. (An alternative way of financing this project thus might be to present it as an ongoing TV series, real-time, from inception to completion, showing also the spinnoffs developed by the Centristation project, such as recycling, agriculture, and group lifestyles in action.)

4. The rotating ring, or toroid shape, has long been in American awareness as the design for a permanently occupied space station, because it provides the artificial gravity needed for normal bodily function. The centrifugal force simulated gravity is assumed to be able to provide the means to overcome the unhealthy effects of weightlessness, such as immune system disfunction, bone loss and muscular atrophy; and allow a human being to have normal bodily functions such as

bathroom activities. And people need the companionship of other lifeforms: the animals, fish and plants also need "gravity."

5. While it is a testing ground for the Stanford Torus Island One much larger design...to be built from lunar raw materials later..., it will test those self-sufficient agricultural processes and family lifestyles in the relatively nearby LEO.The habitat additionally serves as home to workers for adjacent free-fall, hard-vacuum manufacturing facilities, and is comfortable waystation for early manned missions back to the moon and perhaps beyond to Mars' moon Phobos.

(For a free drawing of this concept, send a SASE stamped, self-addressed envelope, to:
JED Cline
CENTRISTATION III
5632 Van Nuys Blvd. Ste. 110
Van Nuys, CA 91401



Above is a hand sketch of the Centristation concept made in November 1989 by Jim Cline

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Number: 2931 Name: CENTRISTATION IV
Address: J.E.D.CLINE1 Date: 930403
Approximate # of bytes: 4666

Number of Accesses: 15 Library: 3
Description:
A concept for a relatively low-cost space station which goes far beyond the current space station's purposes. Would consist of a pair of prefab toroids in LEO, one a zero-g facility and module platform, and the other toroid spinning for artificial gravity inside, as a co-ed crew living quarters and biospheric R&D facility. The toroid's are built of segments, which are first prefab for wet launch, assembled and tested on the ground, then modules are separated and sequentially wet-launched by a reuseable winged engine control module of space shuttle technology.

Keywords: spacestation, centristation, toroid, settlement, biosphere

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CENTRISTATION IV: ECONOMICAL MULTI-GOAL SPACE STATION

By J. E. D. Cline

A BRIEF DESCRIPTION OF THE CONCEPT:

Centristation IV consists of a pair of adjacent toroids in low earth orbit, one is a relatively earth-normal living quarters & biosphere, and the other a zero-g facility. The toroids are built of prefab segments, which are built and tested on the ground first, then disassembled and sequentially wet-launched into LEO by a reusable winged engine/control module. The living quarters is a small spinning hard-shell toroidal space station/colony, with 1-gee internal for earth-normal living inside. The zero-g basic facility is a similar, but non-spinning toroidal shell structure, with internal sealed areas as well as being a rigid platform for mounting of external

modules. The prefab construction, "wet" launch, and minimum modular assembly in free fall is are unique parts of the concept. The segments of the toroids are prefabricated, tested in use on the ground. Then sequentially each toroidal segment dual compartments (appropriately designed and constructed for wet launch) are filled with fuel & oxidizer for use as the fuel tanks for its own launch into orbit, and lifted into LEO by an unmanned winged engine/control module. After orbital insertion and positioning of each segment, the winged engine/control module is returned back to the earthsurface launch site to lift the next toroidal segment/fuel tank.

VALUE:

Minimum launch costs, minimum orbital assembly, artificial gravity for manned portions of living and working quarters, and small-scale testing of toroidal space habitat concepts.

PERFORMANCE CHARACTERISTICS:

All components are either part of the spacestation toroid or are re-used in subsequent launches. Provides hard-shell 1-gee living space for co-ed crew and life supporting agriculture. Pre-assembled on the ground, in adjusted gravity orientation, for extensive testing as a multiperson co-ed living habitat. After insertion into LEO, the segments are robotically moved together to form the toroid, linked securely together, pressurized and spun up for 1-gee inside, all before occupancy by the crew. Access to free-fall equipment is gained through moving through spokes to the toroid's hub.

ENABLING TECHNOLOGIES:

Requires the design, engineering, and construction of a

new launch system mostly using proven technologies. Space shuttle type reuseable liquid fueled engines, winged tiled reusable airframe. Skylab technologies including pre-outfitting fuel tanks for use as orbiting living quarters and workspace; fly-by-wire control systems, re-useable strap-on booster engines; automatic or remotely guided free-fall docking; biosphere artificial ecological system studies; harmonious group studies.

RELATION TO MAJOR SPACE PROGRAM OBJECTIVES:

Provides a rigid basic structure for external material processing modules; economical, high-quality living space for workers in LEO; testing of key concepts essential to artificial gravity space agricultural systems, and later is adaptable for lunar orbit, transit to Mars, and placement in permanent Mars orbit. This has suggested an alternative to the current FREEDOM type of space station, which has been rejected due to excessive costs. This alternative features low cost, much less environmental pollution
during launches, and in addition to providing zero-g basic materials platform, is a major step toward the real goal of space colonization & space resource utilization.

The LOW COST derives from the use of prefab components, requiring very little manned construction in free-fall, and the launch technology being extremely efficient. All components except the launch fuel are either re-used or are part of the space station.

The ENVIRONMENTAL POLLUTION IS MINIMIZED by relatively few launches being required for its component placement into LEO orbit.

It IS A MAJOR STEP ON THE WAY TO SPACE COLONIZATION because it provides living quarters which test concepts of centrifugal artificial gravity in one of the toroids. This project may be able to remind humanity of the purpose of the space program, that of freeing mankind from the ecological limitations of a closed earth surface system, and removing much of the burden mankind has been placing on Mother Earth.

It PROVIDES ZERO-G FACILITIES because a second, adjacent toroid is not spinning and thus provides the stiff shell structure for attachment of various experiment modules that FREEDOM space station would have provided.

REFERENCES:

GEnie Spaceport Library files # 1071, 1537, & 1718, by J.E.D.CLINE1.

(The next item, “WET-LAUNCH OF PREFAB HABITAT MODULES,” is the formally published technical paper on the subject, presented by the author as a peer-reviewed, formal technical paper, at the Space Studies Institute's space conference at Princeton, NJ, in May, 1995. It was the author's first technical presentation at a such a space conference, and done way early on the learning curve. The paper had to be prepared mostly in a two-column paper format following the Space Studies Institute's rigid formatting requirements; and the only means the author had to produce the paper was by using freeware for making posters, enabling the various columns as separate areas in the posters; each page being made as a separate poster, printed out and mailed in. It was nicely published in the SSI's 1995 space conference proceedings; unlike the author's next technical paper, presented at the following conference

at Princeton, in 1997, on the KESTS concept; which was rejected for publication at the time; and in fact, ridiculed. The KESTS concept did not get formally published as a peer-reviewed technical paper until 2000, and then at an American Society of Civil Engineers space conference in Albuquerque, NM. The formal paper on the Centristation concept now follows, reformatted for this book.)

Wet-Launch Of Prefab Habitat Modules

WET-LAUNCH OF PREFAB HABITAT MODULES

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9800 D Topanga Cyn Blvd. #118
Chatsworth, CA 91311

ABSTRACT

It is proposed here that a technology be developed to build space modules which have a dual purpose, that of being both a prefabricated habitat segment and also temporarily being their own fuel tank during launch. Concurrently a re-useable unmanned winged engine control tug vehicle would be developed for the wet-launch of these modules, along with an additional flyback booster. This would provide a way to build economically a large diameter artificial gravity space habitat in LEO in which the majority of its structure would be built and emplaced prior to the first human presence there, reducing risk and cost. The toroidal space habitat would be built and assembled first on the

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Independent Researcher

ground in the form of the dual purpose modules, checked out, then disassembled and launched a segment at a time to the orbital site. Such wet launch enables the tank and launch vehicle structural mass to actually be part of the payload.

A BRIEF DESCRIPTION OF THE IDEA

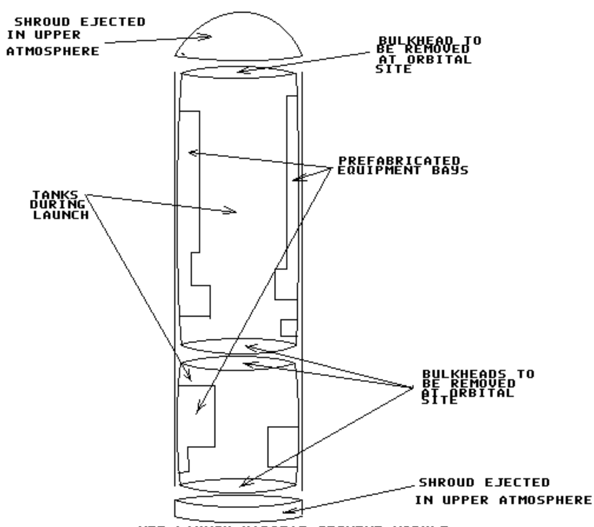
Payloads which have a very large volume/mass ratio, particularly those which are prefabricated segments of a full-diameter toroidal space habitat, can be designed to also serve as their own fuel tank during launch. Flyback re-useable engine tug systems are part of the technology. Utilizing this wet-launch technology, large diameter toroidal habitats can be built in orbit prior to human presence there. [1]

With the development of a specific wet-launch technology, the component technologies used to create the Space Shuttle can be re-configured to enable serious consideration of major space projects squarely on the road to large scale space colonization in artificial colonies in Earth orbit. By the development of a technology for creating shell structure segment modules which are internally prefabricated with equipment, structures and supplies capable of withstanding cryogenic temperatures, and which are also designed to serve as the fuel tank during their own launch into orbit, new kinds of space projects can be seriously contemplated for the near future, particularly those of one- or two-mile diameter toroidal space habitats in Low Earth Orbit. Such a research semi-closed ecosystem habitat would pave the way for long-term homes for space manufacturing employees and their families, resort hotels, and prove out the basic artificial gravity space habitat concept for possible use in a massive ring of space habitats in the Clarke Belt.[2, 3] Focussing on the expansion of human civilization's

well-being, particularly toward the potential of utilization of abundant space resources of solar energy, room to grow, and raw materials, it is conceivable that we could enable expansion of human civilization through space colonization in the near future, to alleviate the ongoing severe pressures on the earth surface ecosystem. The concept of technological re-configuration presented here was developed to be a significant step towards this early large-scale space colonization goal. [3]

WET-LAUNCH MODULE TECHNOLOGY

Building the interior of modular segments of a rotating space habitat to temporarily serve as oxidizer and fuel tanks involves cryogenic survivability, easy purging of residual fuel when in orbit, and easy removal and disposal of tank bulkheads.



WET-LAUNCH HABITAT SEGMENT MODULE

The structural and materials technologies are interlaced. In the design, one needs to frequently refer

to the overall picture, insofar as is possible; in this case, envisioning the completed toroidal habitat rotating in its LEO orbit. That wheel-like structure is an assembly of modules, linked end-to-end, and tensile reinforced by cables circling the toroid, compressing the segments together. Each of those segments served also as a fuel tank at one time, and as such had to survive fulfilling that function during its launch. [1]

To launch a segment of the circumference of a toroidal space habitat while using the segment as its own fuel tank, it must be designed and built to function in the cryogenic environments within its oxidizer and fuel sections. Each equipment bay would need to be adequately sealed from penetration by the cryogenic liquids, or else easily decontaminated. Liners may be useful, to be removed upon initial manned entry of the orbiting space habitat. Residual traces of LOX would dissipate into the air which would infill the module, but residual hydrogen could be explosive or cause embrittlement of some metals. If a hydrocarbon fuel were used, it would need to be scrubbed out, possibly with a detergent. And there are houseplants and bacteria which digest petrochemicals, which might possibly be useful for recycling these residual fuel traces, perhaps later as part of the normal agricultural recycling process.

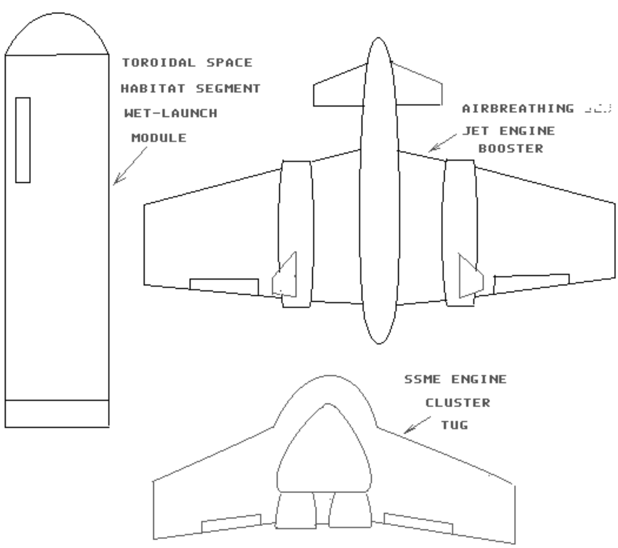
Bulkheads between the oxidizer and fuel sections of the module need to be easily removed and stored, along with bulkheads at the ends of the module. Design of such bulkheads also is a new task.

WET-LAUNCH ENGINES

The engines used to launch the fuel-filled modules need to be re-useable. Drawing from the existing space

shuttle design and technologies, one might envision a cluster of three SSME-like engines, as on the Space Shuttle orbiter, being used to launch the modules. Unpiloted, a streamlined minimum fuselage and airfoil would be included, heat-shielded for re-entry and autopiloted back to the launch site following each launch. [1]

Since much of the payload doubles as airframe and fuel tank during its own launch, minimum booster requirements result. One might alternatively envision conventional air-breathing jet engines, two or three of them, connected by a saddle for the wet-launch module, and an airframe adequate to return it to the launch site following each boost. This craft might be piloted since it operates within the atmospheric portion of the launch.



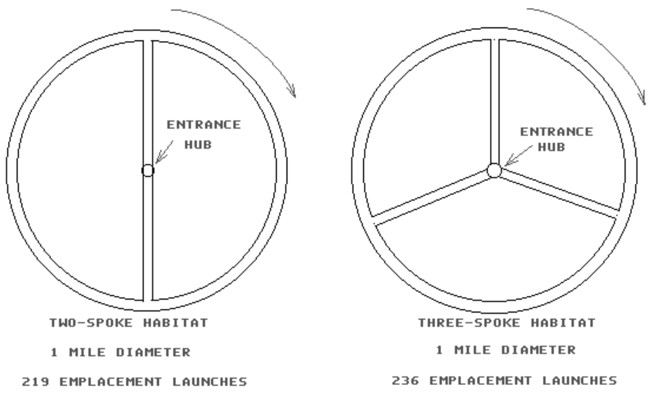
PAYOFF OR VALUE

The value is in the kind of space projects which are enabled by the technology. Developing a wet-launch technology enables near future economical construction of a full diameter toroidal research space habitat, which can lead to large scale space colonization, relatively economical construction of a space resort hotel, and habitats for long range manned space exploration. By enabling economical construction of large scale artificial gravity space habitats, the financing of space projects can be moved from the area of defense and pure science, over to fundings for commercial space resort hotels and even of artificial space habitat real estate development.

PERFORMANCE CHARACTERISTICS

The structural walls of a payload module, and some of the interior structures, are designed to serve as the equivalent structures of fuel and oxidizer tanks during the module's own launch. This technology is limited to the launch of large volume-to-mass ratio payloads which can survive cryogenic temperatures and proximity to wet/gaseous oxidizer and fuels. Engine/control modules and boosters can be autopiloted during launch, orbital emplacement, teleoperated docking with earlier modules, and return to launch site.

Prefabrication and testing of the toroidal space habitat while it is on the ground, then effectively transferring it module by module to docked reassembly in orbit, eliminates nearly all of the dangerous, expensive time-consuming manned free-fall orbital construction time. [1]



ENABLING TECHNOLOGIES OR SYSTEMS

The technologies developed for use in the Space Shuttle and Skylab greatly enable this concept. Flyback systems, re-entry heat shielding, re-usable liquid fueled engine clusters, and the Skylab concept of building a pre-fitted space habitat module into what was originally designed to be a fuel tank area, all particularly enable this concept.

RELATION TO MAJOR MISSION OBJECTIVES

Starting from a long range objective of expanding civilization while removing much of civilization's pressures on the earth's ecosystem, the verification of the fundamentals of space settlement functionality needs to be made. This might be done by building a full one- or two-mile diameter rotating toroid in orbit,

outfitted for use as a nearly self-sufficient space habitat, would test and refine concepts so long held as self-evident, such as functionality of artificial gravity through centripetal acceleration within a rotating wheel-like space habitat, and the myriad interactive functions of a closed-cycle, semi-self-sufficient city/agriculture system integrated with a mechanical structure. With the proof of such fundamental space colonization concepts, serious consideration can be made for the development of massive earthsurface-to-orbit transportation systems such as the kinetic energy supported railway bridge concepts, which in turn enable a vast ring of earthsurface-like space habitats ringing the Earth in the Clarke Belt, a potential home for hundreds of billions of people. [3, 5, 6]

PREVIOUS HISTORY

Skylab was built out of that which was originally built to serve as a fuel tank for an Apollo lunar landing launch.

The Space Shuttle's external tank has tempted many people to dream of its structural use for building a habitat in space despite the large amount of manned free-fall construction effort required.

The concept of a wheel-like, rotating artificial gravity space habitat has been around for at least 40 years, yet one has yet to be built. The tremendous amount of raw materials, and in-orbit manned assembly time has been far too expensive to do, considering the expected benefits of such a construction project.

The Biosphere 2 semi-sealed closed ecological test in recent years in Arizona has been the best prior testing we could do.

LIKELIHOOD OF SUCCESS

Maximum use of existing technologies developed for the Space Shuttle suggest a high likelihood of success of the launch system. Laterally-coupled launch vehicle structures, heat-shield materials, liquid hydrogen and oxygen fuel systems, reusable SSME engines, orbital docking systems, and Skylab pre-fitted tank module experience all contribute to the liklihood of success. Generic basic module structure for the toroidal habitat segments enable relatively quick replacement of modules lost during launch. The technique of building the complete wheel-like space habitat on the ground first, for checkout of the multiple interdependent systems, makes for earlier and easier debugging, thus also contributing toward the success of the mission.

KEY DEMONSTRATIONS REQUIRED

Testing of equipment bays designed to be filled with fuel or oxidizer can be done on the ground. An expendable launch could be modified so its second stage is a test module equipped with prefabricated internal equipment bays, to test survivability of equipment in proximity to cryogenic liquids in launch conditions, ability to purge residual fuel, and operational functionality of the equipment following launch. The SSME cluster tug could be drop-tested and autopiloted to a specified runway landing. The jet engine powered booster needs to be flown as an individual aircraft as well as part of the launch vehicle.

COST TO DEVELOP/DEMONSTRATE/PRODUCE

Wet-launch technology could be tested using an upper stage of an expendable launch to test materials and survivability. Nearly all of the technologies utilized in

this concept already exist, except the techniques for creating modules which are wet-launchable. Thus the cost to develop would be far less than that to develop the space shuttle. Demonstration of the concept might also be done with a specially built external tank used in an actual launch of a space shuttle, although the risk of losing an orbiter cautions this approach. Production costs are lowered due to the large number of similar structures, including the many SSME-type engines, conventional jet engines, and duplicate airframes; the modules themselves would have only a half dozen basic shell types, the rest of their diversity for habitat use would be through individual installation of specific wet-launchable equipment. [4]

MILESTONES

1. Ground testing of equipment bays designed to be in contact with cryogenic liquid hydrogen and oxygen.
2. Launch to LEO of a test prefab module built from a modified second stage of an expendable launch vehicle.
3. Drop test of a SSME cluster tug airframe, and autopiloted runway landing.
4. Flight test of jet engine powered booster as an independent aircraft.
5. Wet-launch of a prefabricated test module, by the reuseable tug and booster.
6. Construction on the ground of a toroidal space settlement, made of wet-launchable segments, perhaps 1 mile in diameter, made of 166 segmental modules which are 100 feet long, with 3 half-mile long spokes made of similar modules.
7. Completion of 236 successful orbital emplacements assembling the first toroidal space habitat in upper LEO. With a booster and tug turn around time of 1 week, and 14 sets of

booster/tugs available, 14 launches per week are made, or two per day. If no modules are lost during the launch series, then assembly time is 17 weeks to complete launch and assembly phase of the settlement, about 5 months to emplace in orbit. A lost module would need to be modified from a set of generic modules, and launched in an added orbital emplacement boost. If each tug uses a cluster of 3 SSME-type engines, and 14 tugs are built, then initially 42 SSME reaction engines are needed for the project.

8. If each booster uses standard commercial aircraft jet engines, then the same 14 sets of booster and tugs initially would require 28 jet engines. If a pair of toroids are built in the project, one spun up and the other left at zero-g, and if an initial 14 sets of booster/tugs are built, then it would take at least 8 months to complete orbital emplacement; if half of the booster/tugs are lost through attrition, then the project still takes less than 16 months to completely launch and assemble them in orbit.
9. Removal of the internal bulkheads from the assembled toroid segments, and purging of residual fuel within it.
10. Launch and orbital modular linking of a second, but non-rotating adjacent toroid for zero-gee materials processing. [6]
11. Arrival of first construction workers, and start up of first habitat quarters area.
12. Stringing tensile cable through loops in the modules to act as safety cable, compressing the toroidal structure and its spokes into a rigid structure.
13. Spin-up of the wheel-like space habitat gradually to a full 1-g at its perimeter. Egress to the habitat limited to through the central hub

airlocks.

14. Stocking of the habitat with supplies which could not have survived the wet-launch process, including agricultural plants and animals.
15. Human population of the space habitat.
16. Stabilization of the system for providing feedback information which coordinates all of the biological, electrical and mechanical systems interlinked within the space habitat.

APPLICATIONS BEYOND SPACE EXPLORATION

Preparation for possible large scale space colonization in near-earth orbits such as the Clarke Belt, which could expand civilization greatly while also reducing the pressure on the earthsurface ecosystem. Space resort hotels, which could provide financing and opportunity for average people to experience life in space.

OTHER IMPORTANT FACTORS

Mankind needs daily drama in life just like the need for food and shelter. Witness the lure of television shows, movies and newspaper headlines. This project supplies the drama of space colonization started in the 1950's, and could begin to be implemented in the 1990's. Life in space needs to encompass all the functions of being human, in addition to being interesting, sometimes adventurous, and potentially within the reach of personal experience of many people in the near future. Life there needs to be shown to be capable of being very comfortable, safe, and supporting all the mating and family-raising activities that humans normally need. The drama of achieving these in the vast room and resources of space can excite the imagination of humanity, supplying a new confidence in the future of humanity and of planet earth's ecosystem. And the habitat could be modified for relocation at Mars' moon

Phobos, or be boosted to GEO if-and-when KESTS (Kinetic-Energy-Supported Transportation Structures) are operational. 1

An alternative way of financing this project thus might be to present it as an ongoing TV series, real-time, from inception to completion, showing also the spinoffs developed by this project, such as recycling, functional understanding of multiple interacting life systems in a semi-closed environment, agriculture, and group lifestyle forms in action. The rotating ring, or toroid shape, has long been in American awareness as the design for a permanently occupied space station, because it provides the artificial gravity needed for normal bodily function. The centripetal force simulated gravity is assumed to be able to provide the means to overcome the unhealthy effects of weightlessness, such as immune system disfunction, bone loss and muscular atrophy; and allow a human being to have normal bodily functions such as ordinary bathroom activities. And people need the companionship and ecological balance of other lifeforms; these animals, fish and plants also need "gravity" to function normally. While it is a testing ground for the Stanford Torus much larger design ... to be built from lunar raw materials later ..., it will test those self-sufficient agricultural processes and family lifestyles in the relatively nearby LEO. The habitat additionally serves as home to workers for adjacent free-fall, hard-vacuum manufacturing facilities, and is comfortable waystation for early manned missions back to the moon and perhaps beyond . [1, 5, 6]

CONCLUSION

Development of a modular wet-launch technology and its specialized launch tugs and boosters, enables the early economical construction of true mid-sized artificial

gravity earth-normal-interior space habitats which have been so long envisioned in the imagination of far-seeing people. In turn, within such a habitat the concepts of closed cycle agricultural support systems can be developed, along with the myriad of other normal life function systems. If the concepts of artificial near-earth-normal-interior semi-closed-ecosystems are proven out, then the serious design and development of large scale earthsurface-to-space transportation systems can be begun. A ring of such habitats located in the Clarke Belt, accessed by surface-to-GEO kinetic-energy-supported transportation structures, could easily accommodate many times the entire current population of our planet, enabling continued large scale expansion of humanity and its companion earth life forms. More immediately, this space launch and construction technology could be also used to build a resort hotel in space, bringing the potential for a real personal experience of living in space to many otherwise average people. Modular wet-launch technology can be a key to true space colonization in a much earlier time frame.

References

1. "Centristation III" by j.e.d.cline1, GEnie Space and Science Library file #1071, December 17, 1989
2. "HWY TO EARTH GEO RING" by j.e.d.cline1, GEnie Space and Science Library file #747, February 9, 1989
3. "6TOGO" by j.e.d.cline1, GEnie Space and Science Library file #4405, April 9, 1994
4. "Toward a Space Habitat" by j.e.d.cline1, GEnie Space and Science Library file #1718, July 1, 1991
5. "Space Settlements, A Design Study", NASA SP-413, 1977
6. "Centristation IV, Multi-goal Space Station" by j.e.d.cline1, GEnie Space and Science Library file #2931, April 3, 1993

The Home Manufacturing-Education Workstation Concept

Background: This concept originated in the creative writing of the novel "Building Up," instead of beforehand as the other concepts had been previously formulated. It was not begun to be formalized into a current time frame until the currently ongoing unemployment crisis began; it was then formulated to enable just about everybody to contribute to the gross domestic product of the country, regardless of their lack of a formal corporate job, at whatever level they were able to participate in, done from home so the commute costs and environmental effects would be minimized; and each person could work however much or little as was within their comfortable capacity at the time. The jobs could be coordinated by businesses, corporations, or simply as freelancing work. The on-the-job training could be done right at the home workstation, and probably much of what is taught in formal education could be learned at home this way too, all coordinated through the internet.

Here is the author's writeup on the concept as it stands now; there has been no interest expressed to me by others for this concept yet, so we are still stuck with "business as usual" limits on jobs and productivity.

Home internet-linked manufacturing workstations

James E. D. Cline

Purpose

To get everybody into the productivity loop while expanding their capabilities, in a useful, time and energy efficient way, that provides increased manufacturing productivity and education both skill-specific and general; all done efficiently from a new

type of workstation utilized at home. Adequate energy, adequate human resources, and adequate communication and transportation, are as central to America as it is to civilization. As is adequate productiveness to match the needs of the nation and its place in the larger world economy. A project to simultaneously improve all these factors is proposed herein.

Background

As America is using 25% of the world's energy while producing only 3% of the world's energy, clearly energy is a key issue. Somehow, the two numbers need to be brought into equality. Many means for bringing wind and direct solar energy into the system have long been discussed elsewhere.

The existing trends of approaches to solutions are necessarily to be made with minimum change involved, such as merely upping the fuel efficiency of the average car; that is an achievable goal if it is the goal instead of business profits being the prime goal; I drove a car that would meet probably 80% of the average commuter and housewife transportation needs and got 42 miles per gallon when cruising at freeway speeds, roomy inside, safe and very easy to drive, it was built 19 years ago; a 1990 Honda Civic Hatchback, fully equipped. Surely that same vehicle could be being mass produced again today, if it had been built 19 years ago. But corporate egos, franchises and excessive profiteering is in the way of doing that; and clearly we cannot overcome that problem even now, even to help save the nation.

Yet, even doubling the average car's fuel efficiency, does not bridge the great gap in energy usage vs energy supply in the nation. And in fact, the vehicular

efficiency is part of a national system that can provide for the adequate energy, human resources, communication, transportation and productiveness. Putting patches such as raising fuel efficiency standards for car manufacturers, is needed as soon as possible; yet, there really needs to be an eye toward what could actually adequately meet the goal requirements in a time frame enough to rescue the nation.

Human resources are also key to solutions. It is said that wasting a human life is a terrible waste indeed. For example, the huge majority of senior Americans, life after retirement could well be much less wasted, if some principles were enabled. Indeed, the enabling of efficient partial productivity could extend to many other categories of people, especially the folks who are unemployed between “regular” conventional jobs. But for now, let's focus on those senior folks who are "retired" and struggling to live adequately on Social Security retirement; thankful as they are on this provision for their present and future, maybe there can be more to life for them, beneficial to everyone while making them feel more useful and interested in life's activities.

Something of the "volunteer" quality to the activity, in that it involves voluntary participation doing things the person would like to do for the experience or for the sense of doing something worthwhile. Working at one's own natural pace at the moment, for the reward of just doing it, as well as financial reward and other perks. Activities which have been designed to add a cheerful and fun quality to some extent; no ogres and slave-masters permitted here; life is to be made more fun and with a sense of being worthwhile for both the individual and the group, the nation, the world, civilization, the planet.

Perhaps as important, is the potential to make America again competitive in the international manufacturing system, which has now mostly gone offshore to other countries. We could again produce a significant amount of what we consume of manufactured products, and surely have some to sell to other countries in return for what they make over there and we buy over here. We Americans get back into the manufacturing game, as well as some other forms of human useful productive function currently not economical to be done here anymore.

Thinking of the American view, of the country; and disregarding for this abstraction, the plethora of franchises, territories, and domains virtual, real or implied that will need to be consulted before real implementations.

Key to the solution is the vision of the whole picture; and the endless questions of does a proposed change get us closer to the goal or not, and what does it do to the myriad other factors in the overall picture. Some potential approaches would have a more interesting appearance if the whole picture is referenced.

The integrated Home Workstation Approach

Consider the concept of home-sited manufacturing & educational workstations, linked through the internet, unified by corporate or small business management; including delivery services' shuffling of subassembly kanbans between homes. Those home workstations being also set up to be on the job training workstations, including providing practice in between real job productivity items done there too.

Such an approach is that of bringing into reality a whole new technique for getting things done efficiently in terms of energy, time, and human resources for a new category of national productiveness, by creation of an economy stimulation through creating a nationwide at-home manufacturing workstation system. The use of parts & subassebly transfer between various home-sited workstations could be largely done by use of the "kanban" or box technique (referring to the “Just In Time” produce-on-sales-requests technique of the 1980's) subassembly and internet-coordinated and in some case partially teleoperated equipment for various kinds of manufacturing steps done at home, coordinated by small and large business management which is in turn managed by reference to the entire needs of the nation.

Initial goal would be for part time work at home with these home workstations. They could be used a few hours after a regular 9-5 job workday, instead of commuting to a second job to make ends meet. Yet they would have the ability to provide full time employment where appropriate.

The home workstations could be part time work for the unemployed, doing make-work that builds up their skills for when real work becomes available. They would be used for retired people, to get them back in the work force, at their skill level; this could boost their self esteem as they continue to contribute to the GNP even after retirement, when no full time job is practical for them. Aptitudes, rather than prior employment, would be the determiner for who does what on these home workstations. Those people who are unemployed by conventional businesses or corporations would no longer have to merely wait until somebody wanted to hire them for awhile; they could be in the productivity

loop immediately upon loss of formal employment, no longer totally at the mercy of the whims of corporate business needs.

Testing of aptitudes, much like the on the job training from the home workstations, would be done at home too.

Continued monitoring of quality and quantity of work from each workstation and person over time would provide additional data for potential for further jobs they could do, including change or upgrade to the particular type of fabrication or testing workstation.

These home workstation's design and fabrication would provide new business opportunities too. They could be of many kinds and be designed for modular add-ons for adding versatility; each would include common computer workstation functions much like already exist, as linked through the high speed internet, along with small scale tooling for manufacturing subassembly steps, some of which could be done teleoperated from elsewhere in some steps such as micro-assembly parts, analogous to electronic "pick-and-place" assembly of tiny surface mount parts on circuit boards common for decades. drill presses and similar small scale machine tools would be part of the workstations, as well as precision measuring equipment, especially suited for the home workstations primarily involved in quality control.

Instead of the commuter intensive transportation system we now have, this would then change to a delivery-intensive transportation system. The movement of the "kanbans" or packages of subassemblies between the various home workstations would become the domain of the delivery service providers; initially this could be the existing carriers

such as the US postal service, UPS, Fed-Ex etc, as well as more local enterprising delivery such as by teenagers with small delivery trucks working within a smaller neighborhood subset. The tracking of location and movement of these "kanban" packages would be a prime function, possibly utilizing GPS tracking systems.

Existing types of video-chat systems can provide much of the face-to-face type interactions as needed between management and employees. Existing homes often have rudimentary computer, much less versatile, workstations for internet and game use with computers via the internet; such sites would be useful for addition with the workstation locations. The same combination of computer and manufacturing equipment of the workstations would also be adapted to on-the-job training and generalized home education, expanding the capabilities of the employees right at their workstations. The more versatile the workstations, the greater the potential for performing a wider range of kinds of processes as becomes needed by the national productivity's evolving need set.

Referencing the common terms "telecommuting to work" and "home business" perhaps these concepts could be expanded intelligently. People would perform some tasks at home that might otherwise be done in some business or manufacturing physical site. Computers and the internet have potential to link it all together on the informational level and the managerial level. Where there is physical product involved, the USPS, UPS, Fedex type services could pickup and deliver between homes and distant destinations; and among local neighborhoods, some people could shuffle containers of subassemblies between homes in a certain area which coordinate to build a specific product. A system like the old Japanese Kanban system of a container which carries a partially

completed product, along with a checklist of what needs to be done to produce the completed product, moves from station to station until it is finished and tested. Each station receives a Kanban, removes the partially finished product from it, reads the instructions, adds parts to the device as is defined by the parts on hand from separate source, using the person's skill and tooling on hand. Then the Kanban is then moved to the next station for the next step in assembly; at times, a station does not add to the assembly but instead applies quality control measurements and testing to verify it is up to spec so far. Eventually the Kanban reaches the end of the stations on its checklist, after final inspection, and gets boxed for shipment for use by a customer.

In the system being envisioned, however, the Kanbans are moved from home to home, instead of workstations in a large manufacturing facility. A lot more time and energy is involved in the processes of shipping from home to home; this is less efficient. However, looking at the overall picture, energy efficiency is improved by the employees not needing to commute back and forth to a common manufacturing facility; and the resources that would have been consumed by the manufacturing facility are saved, in the big picture. But from that savings consider the reduction in efficiency required by usage of home space for the process, perhaps involving construction of an added room, instead of using a room vacated by departing children as they grew up. Specialized tooling such as computers and microscopes and drill presses might need to be acquired for the particular kind of steps that are done at that home facility.

More inspection time would be needed, sometimes repetitious, which reduces efficiency. So, lots of plus and minus for the evaluation of this concept. The big

plus is that people who would not have otherwise have been in the productivity loop, are back in it again, even though at a lower productivity rate. One-quarter of one-time level of full productivity is a lot more than no productivity, for example.

A goal of the system would be to get everybody into the productivity loop, doing one or more functions, and being compensated for doing that function. At first, whoever is making this all happen, is likely to create tasks of the nature of "digging holes and filling them up again" to do, such as picking up trash from the street and putting in garbage cans, or taking some gadget apart while somebody else puts them back together again, just to get the feel of doing it all in a coordinated fashion. Eventually slip in some paying item for assembly or disassembly; like shifting from taking apart wrecking yard car alternators or engines piece by piece and putting them back together again along an assembly line among many homes, to the assembly and inspection of new engines, for example. Practice makes perfect and the experience is what counts at this point; in the KanBan system, each workstation (each home facility in the proposed scenario) includes ability to set up and use several kinds of tooling; and daily activity involves learning even more new kinds of knowledge and acquiring new skills as part of the daily routine.

People could become known, via their practice and performance, for their ability to make clean 3 mm holes drilled in 0.5 cm steel plate; or the programming of a small benchtop assembly robot to do a microscopic subassembly of a certain form.

Result is first to have people, all people, find a new level of usefulness in their life, whether a teenager looking for a first job; to a housewife with 15 minutes

available off and on in her daily routine; to a retired senior who still has a lot of mileage left, just not at full speed, yet still can get there. "Homeless" people could be brought into the loop, with tasks found to be at their level for their self-esteem and a bit of productivity in it all somewhere. Not wasting all those partial human lives is a national reward as well as to the individuals; and the country may once again be able to produce some products at low enough overall cost here at home.

Educational expansion aspects of the proposed project

Re education, I would suggest very intense looking into the use of the internet and television for educational purposes, since the classroom setting is not necessarily the optimum educational medium for all subject material; we learn quite well by example's set before us.

For an obvious example, programming of televised educational shows could be like Sesame Street for adults too; imagine enjoying learning calculus that way. And the interactive potentials of the internet and web browser technology has enormous potential for designing online course material where problems are shown, ways to solve the problem are shown, then problems are shown to the student and the student's answers evaluated online as to adequacy and where necessary new problems and their solutions are put before the student until the student gets it right, every time. Learning course material could then make every student an "A+" student; some will learn faster than others, but then there will be no missing pieces as in a "C" grade education.

However, the computer screen display still has some quirks that need to be resolved or bypassed in such education; the well-known differences between paper versus computer screen, even the LCD screens. Artists still have to make an initial artwork on paper, then use the computer to create it digitally; somehow it does not work well when trying to do creative art directly onscreen, ask the artists. And similarly for "left brain rational" data input, the on screen display still has a problem needing analysis and resolution, which I, as an excellent speller from childhood, puzzle over, a demonstrable and repeatable phenomenon that I can compose and write online and go back and correct my spelling - if unassisted by the spellcheck, of course - and the paper will look spelled correctly to me; but if I then print it out onto paper, and look at it, almost invariably my eyes will spot more spelling errors almost instantly, ones I could not perceive when it was on screen. Research into these two phenomena, the art one and the spelling improvement one currently needing doing on paper, would need to be completely understood and resolved first. Using the normal spell-checker on the computer only compensates for the problem, it does not fulfill understanding nor truly solve the problem, which probably has more far-reaching effects that are critically important, too, before education can be fully reliable via the computer screen.

There is also much need for far more versatile input devices to the computerized educational system than just the keyboard and mouse, powerful as those widespread input devices are. Possibly computer game type controls might need to be integrated into such educational systems using the internet. In some course material, three dimensional viewing may be needed; so adaptations for that need to be developed for education, such as wearing alternate-side-switched glasses driven by the computer which is alternately

showing the view from the two stereo sight positions, so to the mind there is 3 D in motion.

Such increased remote educational capacity would directly integrate with the home manufacturing workstations, utilizing the expanded computer-machine interface to people. The above-mentioned input and output versatile systems (and eventually developing full-body-sensing computer input devices) thus created for educational systems online, could be adapted also for performing telecommuting activities via the internet from home, directing machines to do the required actions to build and test and repair products, as if the operator of the tools were actually on site in the factory. This would have advantages of greatly reducing the fuel consumption to commute to the job each day, but also eliminate the commute time; and would also enable scale conversions such that a person could be observing what appears to be easily handled items being worked upon, when in reality the machines are actually manipulating microscopic devices; or visa versa very large items, with the person operating the equipment from the comfort of home, not focused on it being tiny or huge, but of just easy handled size to the senses.

While we skirt the complacency of "business as usual" failed policies of the recent era, since corporations do not take on the responsibility for providing jobs for the workforce; they are there just to produce in their specialized arena as efficiently and profitably as possible, and care not at all for the big picture in which they exist. To get past these ways, we will need to find a comfortable eyes-wide-open level of monitoring the results of our changes to the systems, intelligently and compassionately resolving the unexpected interaction issues as they are first spotted as we go along. And life could become lots more interesting as a result of all

this, too, as people drift out of the couch potato zonked in front of TV sports munching MSG-laced fast food mode, into far more enjoyable forms of living consciously and actively healthily.

Intended Results

This concept has potential to bring back competitive manufacturing to the United States, through massively boosting productivity and skill expansion, by enabling part time work at home to match the abilities of all classes of people including retired seniors and young people looking for their first formal jobs; changing the transportation system needs drastically through elimination of much of the automotive commute system, and being more time and energy efficient due to the elimination of the daily commute to a worksite.

Reference Background material

http://kestsgeojedc.blogspot.com/2009_01_01_archive.html

Prepared on April 10, 2009; Ephrata, WA, USA.

Kinetic Energy Supported Transportation Structures to GEO

The energy potentials for inexpensive access to Earth orbit had been established – a mere 7.3 KWh of energy was given to each pound of mass by moving it from the ground up into GEO, typically about 73 cents of electricity per pound lifted up there from the ground - and yet the physical means for doing it was not yet apparent. Elevators, railroads, needed to be built to reach to Earth orbital altitudes to provide adequate transportation from the ground up to there, and yet how could that actually be done? Structures were known to be able to be supported, shaped and strengthened by the omnidirectional pressure of kinetic energy stored within the structure, such as the pressure within a balloon transforms it from a limp bag into a fairly large rigid shaped structure; and the whirling of a lasso transforms it from a limp pile of rope into a fairly rigid large circle that can be thrown to encircle something. Could an electric motor be built to function much like the lasso, and be so large as to encircle the planet in an Orbital Transfer Trajectory shape, supporting its own tubing to exclude the air near the ground for its high velocity encircling the planet? Such a structure perhaps could finally provide the means for economically transporting the material for building a wide array of huge facilities in high Earth orbit, such as the long envisioned Solar Power Satellites needing built in GEO, to finally provide all the clean electric power the nations of the world needs. And the material being lifted could even hitch a ride on the upward-moving part of the “lasso” so as to lift it to space, and thus not need to lift the weight of any fuel for its journey, thus bypassing the great handicap of conventional rocket transportation to space. Follow its development in the following pages.

Stirrings of some of the principles of such a structure began to be formed in the mid-1980's with such concepts as Keith Lofstrom's “The Launch Loop,” Rod Hyde's “Starbridge” and Earl Smith's “The Texas and Universe Railroad;” yet all had unworkable parts or fell far short of what was needed for full transportation between ground and GEO, where the Solar Power Satellites needed to be built in great abundance and as soon as possible. The author found himself on stage in front of three commissioners of the National Commission on Space in November 1985, giving the following testimony urging pursuit of these concepts. The talk was later used as the first of the author's files on the newly available Genie Spaceport Library, as file # 475:

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Number: 475 Name: SPACE INSPIRATION
Address: J.E.D.CLINE1   Date: 880702
Approximate # of bytes: 11340
Number of Accesses: 41 Library: 3

Description:
Need for international cooperation in space
Five unusual forms of space transportation
Need for whole brain thinking in space planning and operations

Keywords: transportation, shuttle, Mooncable, Starbridge, synthesis
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Adapted from testimony given by J. E. D. Cline to the National Commission on Space, on November 14, 1985 at the California Academy of Science, Golden Gate Park, California.

In enthusiasm for the future of mankind, let's build and

maintain an open door now for our future, into space and back. This can prepare a way to maintain a high civilization advancement rate without destroying the ecology of Mother Earth that bore our physical development up to this point and is now supporter and host to us.

There is urgency to creating a permanent open door between Earth and space. The rapid rate of loss of high energy density fossil fuel resources could permanently close the door to space for humanity, for example.

There are five types of interesting space transportation projects which I am going to briefly bring to excite your imagination here. But first, I am going to point out some significant sociological, psychological and material benefits of a massively expanded space program.

An initial benefit is that of greatly increasing productivity at home, and then spreading out internationally, as people become inspired by the visions of new hope for mankind's future: theirs and their children's children. As the basic task is for all humanity, and indeed for all Earth life-forms ultimately to benefit, discoveries of new depths of international mutually-respectful togetherness action toward common goals would be learned...hopefully in a wise manner.

For example, the ancient oriental cultures can teach us to combine the types of thinking of both our left and right brain hemispheres, linking the highly educated analytical left brain hemisphere with the great non-verbal design-synthesizing prowess of the brain's right hemisphere.

And then there is the hope for reasonably early return of large amounts of useful materials processed in space so as not to pollute the Earth environment with

industrial process wastes. Made available to people here on Earth, materials like foamed-steel could be used for lightweight fireproof housing construction, and the construction of energy-absorbing freeway crash barriers.

Perhaps more subtle than the urge to ensure a maximum of life options for our children, is the urge for adventurous stimulation of our dreams and actions. So here are a few space transportation projects which I would like now to bring up for your attention, perhaps with some uniqueness.

The first is a combination of several contemporary concepts: to close the energy cycle for the space shuttle main engines, its hydrogen and oxygen fuel would come from electrolyzed seawater made through the use of energy beamed down from a dedicated prototype small Solar Power Satellite in geosynchronous orbit. Another plus is that the microwave beam is there for lift energy for experimental vehicles riding up, possibly using the air it initially passes through as reaction mass for the early boost phase.

The second concept is someone else's: the dynamically-supported earth-tower proposed by Ron Hyde of LRL. An immense transportation tower reaching from the surface of the Earth up through the atmosphere and out into space, it overcomes the inadequate strength of existing materials for such a structure through using stored-energy for the main structural support. Rather large amounts of electrical neergy is used to accelerate vast quantities of berylium disks, whose energy is then used to support the elevator and structural components by sharing a bit of their energy electrically as they whiz by. The system stores several days' worth of supporting kinetic energy

for the inevitable powerplant down-times. A large version of this "Starbridge" elevator would be able to lift the mass of all humanity out into space in a matter of weeks (if there were a place built for all of us out there!) In caution, one is reminded of the lesson of E-temen-an-ki, the biblical "Tower of Babel" that also was "to build a skyscraper building so tall as to enable man to enter the heavens." It's construction was said to have been halted because they failed to learn how to truely communicate first. (Confound it!). Ron Hyde shared this concept at a L-5 meeting in 1983; the basic concept of a centrifugally-supported Earth tower had been proposed by K. Tsiolkovski in 1967. Ron Hyde's proposal would overcome the difficulty shared by both E-tamen-an-ki and Tsiolokovski: there are no known physical materials nearly strong enough to do the job.

The third concept is based on an analogy of the "siphon", which is a device which lifts material up over a barrier and down the other side, without addition of energy from the outside, once started. It is powered by the energy differential existing between the starting point and the destination point, and works only in one direction. The gravitational space directly between the Moon and the Earth might be envisioned as a gravitational hill with a shallow valley on one side (the Moon"s surface), and a deep valley on the other side (the Earth's surface); the peak of the hill is known as "L-1". Can we tunnel through this hill from the lunar valley floor? A siphon does that, energy-wise.

Here on Earth, we can siphon water through a rubber hose. Out there in space, siphon-like action might be achievable by transferring energy from mass on the downhill (earthside) part of the trip, over to lift more material on the uphill (Lunarside) part. Electrical superconductor rails could be installed on a supporting tensile structure fastened on the surface of the Moon,

and electrically transfer the kinetic energy from descending electrical tractor-generators carrying payload mass, over to lift more payload mass up off the Lunar surface via electrical tractor motors. Space-rated fiberglass is quite strong enough to carry the load if it has a tapering cross-section; glass is an abundant material on the surface of the Moon, available on-site for construction of this "Mooncable". At the L-1 balance point, in zero-gee, the main portion of payload mass would be cast into glider shapes, so that after traversing the earthside part of the cable, it can drop to glide the atmospheric portion of the trip to landing in oceans off seaports on Earth. I proposed this confidentially to NASA early in 1972, describing it as a profit-making enterprise.

The fourth concept is the use of a kinetic energy transfer shuttle. In permanent eliptical orbit around the Earth-Moon pair, and with its main part massive enough to stay "cool" inside even in solar flares' radiation times, it dangles a rope to graze the surface of the Moon as it passes by the far side of the Moon. Readied payload on the Lunar surface grabs the long dangling rope (sometning like Hans Moravec's Skyhook would have done on Earth), jerking it up off the surface and storing its energy by whirling around the main mass. The whirling continues as they go along the quasi-elliptical orbit until it passes near the Earth, then with precisely synchronized timing the payload is released, restoring the kinetic energy taken when lifting was done at the Moon. The transfer shuttle then continues on around Earth, and heads back toward the Moon again. (Grab on at the Moon, whirl your energy until you jump off near the Earth.)

The fifth and last concept I wish to point out now, to inspire fresh creative thought in space transportation concepts, might be called "tight orbiting" somewhat

cryptically. We would need to find the strength of contemporary materials is enough to enable construction of a vacum-enclosed, above orbital-velocity spinning ring-pair. Even at sea level (for example) each element along its circumference would be at 18,000 mph and thus in orbit there, enclosed inside a vacuum housing. Faster than 18,000mph would possibly exert a force toward a higher orbit, possibly lifting payload with it. A pair of contra-rotating parallel horizontal spinning rings, driven and supported by appropriate magnetic fields, would hopefully cancel out the urge to precess (my thinking gets uncomfortably fuzzy about here); otherwise it would have to built near an Earth pole to keep it from tilting itself as the Earth rotates. Questions are: will it stay together? Does faster mean that it will go up? How small can it be made?

As a 17 year old boy, I and my cousin Howard tried to see if a gyroscope could be spun up fast enough so that its circumference would reach orbital velocity at the Earth's surface. The thought was more toward the idea of using it to fling a something off its edge up and out toward space. We used a big 3600 rpm electric motor and rigged up suitable belt and pulley ratios for the experiment. However, long before it got up to that speed, we discovered the limits to the strengths of materials, and with a bang the main gyroscope spinner exploded, vanishing from sight. That the fragments missed both of us is memorably quite a relief to this day.

There is danger in building the doors opening the future of Earth lifeforms to space, but there is adventure there too, to stimulate the human organism with delightful excitement!

This general concept of the space program is really about caring for our civilization's continuing

advancement while caring for the needs of the other kinds of living creatures with which we share this earth. By bringing our life to the now-lifeless parts of our solar system, and taking the industrial load off of Earth's ecology, we gain immense resources of material energy and room, and make a way to begin the healing of the wounds of planet earth's living ecosystem. Out there in space we can build our living space just as we choose it to be, made out of extraterrestrial materials.

Those of us who are here-and-now action-oriented people, are the "do-ers" who can make these visions physically real. One task we have is to find ways to prevent these ones of us from becoming overwhelmed by visions of power struggle games, with blaming finger ready to point away from themselves. We can do this by continuing to help them remain aware of the greater vision, of responsible belongingness as part of creation, yet in adventure.

Our abilities to exert power over our environment and to analyze our activities are tremendous. To these, then, we need to add equally powerful abilities to pattern whole designs of envisioned possibilities. Technological adventures can evoke designs of exhuberantly happy lifestyles for our children, and maybe even for ourselves...if we are quick enough.

Thank you!

By James Edward David Cline

But this appeal was ignored, and not mentioned in the resulting report of the NCS, which limited itself to what could be done with the conventional, rocket-propelled vehicles, preferring to adventure to Mars instead of

utilizing the resources of space much nearer to home first before heading off far away for adventures.

What was wrong with the approaches of Loftstrom, Hyde and Smith? I sought the technical reasons (not yet realizing that there were vested business interests and political reasons dominating the scene) perhaps to then blend them into some composite which would be more likely to work. It took a couple of years simmering in the back of my mind, and then suddenly the beginnings of what became known as the KESTS concept jelled. The newly available public computer network Genie with its space activist group seemed a perfect place to start sharing these concepts, and so a series of files were written an put in the library there, using the 300 baud modem my Adam Coleco computer utilized. Here are some of those files. Here is one written in October 1988:
****

Number: 578 Name: MICROELEVATOR VERS. 1
Address: J.E.D.CLINE1   Date: 881011
Approximate # of bytes: 8820
Number of Accesses: 18 Library: 3

Description:
Brainstorming on creation of a micro-sized space elevator from Earth-surface to geosynchronous orbit. Intended to demonstrate potential for a full-scale version and to provide limited actual delivery service. Concept stimulated by "Launch Loop" and "Starbridge" concepts; intended to bring attention to them. All readers are invited to participate in evolving this conceptual synthesis.

Keywords: Starbridge,Launch-Loop, transportation, synthesis, microversion, Earthtower, Microelevator
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MICROELEVATOR:Version 1
by J E D Cline   Oct 8, 1988

Proposing the creation of a micro-sized dynamically-supported space elevator extending from Earth-surface out to GEO, to capture public attention to the potentials of concepts such as Hyde's "Starbridge" and Lofstrom"s "Launch Loop", and to provide limited delivery service to space. Inviting all to join in a group creative process with the intent of accelerating completion of the detailed conceptual synthesis in all aspects, and actualizing it within, say, 10 years.

New ideas grow from existing ideas which grew from the old ideas. Be part of this growing-idea process.... All readers are invited to participate in the evolution of the synthesis of this concept. [This can be a project that has a life, a beingness, of its own, like a living entity.] It is humanitarian in nature, intended to accellerate the constructive expansion of civilization into space, taking the load off of Mother Earth.

Maintain a playfully adventurous cheerful altruistic attitude, while participating in the growth of new concepts. Structures which form the basis for transporting payload from the Earth's surface into space have been proposed for many years, yet we aren't building them yet. Their potential for accelerating the journey of mankind into space settlements is incredible and potentially near-future, technologically speaking. Herein is proposed a way to demonstrate feasibility through building a backyard version first. Although not quite the concepts of Starbridge and Launch Loop, it is similar enough to gain attention to those brilliant concepts, and perhaps form a limited version of a useful transportation system itself.

Brainstorming to conceptualize a micro-sized system, something that raises itself from the ground in some place off the air traffic lanes, and extends upward resembling a kite string all the way to geosynchronous orbit, then retracts itself back to earth surface again. Would that get public attention and industry support? Picturing the "kite string" as a pair of tubes (one for upward flow, the other for downward flow) size of ...0.02 inch diameter each would require a storage volume equal to a cube only 50 feet on a side... charged electrostatically (or alternatively centered electromagnetically) to frictionlessly center a very high velocity fillament, or stream of charged matter, within the pair of tubes. Perhaps the tubing is made as an electret, charge directed inward, and the filament an insulator...glass?...which is a coating around a very fine ferromagnetic material. Electrostatic bearings for this microstructure concept is thought less complicated than an electromagnetic bearing structure. The ferromagnetic material in the center of the filament is used to be the armature of the accelerating linear induction motor, and to magnetically couple enough drag on the filament to support the tubing enclosing it, which has magnetic material laced through it for that purpose. The upper end of the tubes has a rotational reflector, diverting the upward stream flowing within one tube, around and down the other tube. Push is exerted by that reflection process. The push is on a remote-controlled tiny craft, which thusly accellerates upward trailing the stringlike tube-pair as it goes. At the origination site, the tube pair is stored in a large ring from which it is being de-spooled. This ring also is the toroidal stator for the induction motor for accellerating the wire/stream within the tube. Thus the wire/stream is continuously flowing in a giant loop, coiled long enough to go round-trip to GEO, 22400 miles up and back.

The craft continues upward, pushed by the process of reversing the direction of the mass of the high-velocity filament in the tube, remotely guided to accomodate encountered winds, like a kitestring headed upward. After reaching the vacuum of space, the craft uses energy from the wire/stream within the tube pushing it upward, to accellerate reaction mass in appropriate directions to guide it as it continues its ascent toward GEO. Once at GEO, it proves its achievement either as a radio transmitter turned on inside it, or by having the craft covered by optical/radio retroreflectors, and ground stations are invited to triangulate upon it, proving it's existence there. The velocity of the wire/stream is then decellerated to reduce the upward urge, and the tube pair is pulled back down to Earth surface, re-spooled into the large ring from whence it was first set on its journey to GEO. (Alternatively, one could use this system to deliver the filament material to GEO at a respectable rate...material for use in building structures in space...say, a 2 mil diameter glass filament with ferromagnetic inclusions delivered at a rate of say 8 miles worth a second, accumulates respectably). Bids are then taken for building large commercial versions for use in putting comsats in GEO, and for building a permanently-erected version supporting a maglev Earth-to-space elevator, powered thereafter from a small Solar Power Satellite at its GEO terminal, using relevent concepts from Lofstrom's Launch Loop concepts, and Hyde's Starbridge concept.

This is one of two primary versions, the quasi-linear, or UP-DOWN, version, based on the "Starbridge" concept proposed by Hyde. The other primary version, based on the version of Lofstrom's "Launch Loop" as envisioned in Earl Smith's "Texas and Universe Railroad", is the quasi-elliptical, or AROUND, version, is very similar, except that it has a nearly horizontal contact point with earth-surface, and encircles the

Earth, reaching geosynchronous orbit on the far side of Earth before returning to the origination point on the surface, continuing the loop. This second version has a minimum of centering force required inside the microtube.

Thusly the public's attention would be captured through a real demonstration, and press releases are then sent describing the visions of the futures possible when full scale versions are in operation, transporting billions of people toward space colonies built in space, initiating true space settlement of a spacefaring people.

Microelevator conceptual snapshots:

payload is a stretchable filament or discontinuous filament sections thickening at top due to slowing reaction engine atop at GEO to hold in place; or open tube end to release the stream of mass to stop "push" while there; or stop at equilibrium point short of GEO (very thick tube at that point?) to cancel lateral thrust at top-end direction-reverser, have two filaments, which go opposite directions to rotate downward, then rejoin for trip back to Earth

push=F=ma

a=say 8 mi/sec, m=0.83 lbm/in3, vol = 2E-3in2 * pi*8 mi

tube of carbon-fiber-epoxy matrix--keep out air where in atmosphere

constant "current" all along length, constant mass/sec throughput...means thin where fast, thick where slower.

I invite those with appropriate skills to put numbers to it. Questions and answers, anyone? Whenever bugs are found, please communicate them to me, so that I can

re-synthesize the concept, for re-uploading to GEnie Spaceport library for further serious playful thinking/imagineering by interested persons, involving this way to create a highway to space.

Replies can be uploaded to GEnie Spaceport library; GEMail to me using address of "J.E.D.Cline1"; sent to me (JED Cline) at 5632 Van Nuys Blvd. #110, Van Nuys, CA 91491, or phoned to (818) 909-0143. Thanks and have fun with visions for a new future!

Start of reference list of idea stimulators:

Lofstrom, Keith H., "The Launch Loop", ANALOG 1983

Smith, Earl, "The Texas and Universe Railroad", L-5 NEWS Nov. 85 pp9-11

Drexler, K. Eric, "Engines of Creation", Anchor Press

Cline, JED, "Space Inspiration", GEnie Spaceport library file #475

Cline, JED, "Power + Transportation", GEnie Spaceport library file #553

By February 1989 the concept had become as follows:
****

Number: 747 Name: HWY TO EARTH GEO RING
Address: J.E.D.CLINE1 Date: 890209
Approximate # of bytes: 15120
Number of Accesses: 17 Library: 3

Description:
General audience writeup of the kinetic-energy-supported space elevator structure concept, providing economical transportation into space at high payload

volume, primary power from SSPS, including surplus power delivered to earth; spacecraft construction at GEO, Stanford Torus type space habitat construction at GEO.

Keywords: elevator,habitat,torus,transportation,power

HIGHWAYS TO THE EARTH GEO RING

J. E. D. Cline

Fortunately, the resources of energy to make things happen, raw materials for building things, and vast room to live in, so needed now to take the burden of mankind's greatness off of the ecosystem of our Mother Earth, is available in space. Those resources are close, starting only ninety miles or so away, 90 miles straight up overhead, that is.

Although that ninety miles is a steep climb, one which the world is currently able to make for only a few people ata time (without much of a place to go, either; no hotels there yet) aboard chemically fueled spacecraft like the space shuttle, the key links for creating a true highway for the bulk of humanity into space may already exist in concept. Let me show you a neat design for connecting those links into a unified picture of Earth's ecological system, human civilization and highways to space habitats.

First we need a hypothetical belief that it can be done, can be achieved, and done well. That belief will lift us up out of appearant dead-end tracks along the way, energizing us with a reminder of the whole picture, the map. Yes, we CAN get there from here.

Next, a quick reminder of why we need to do it. Like

humanity eliminating forever one species of earth life forms every week or so, mostly in the rainforests being slashed and burned for farm land, then exhausted to waste land. Add to the list that the arid waste lands of the entire world are collectively expanding at the rate of about 40 square miles per day. The Sahara desert once was a well-watered savannah. We are burning up many billions of dollars of fossil fuel petrochemicals every year, and replacing none of it. Worldwide we pile up one billion tons of garbage per year, putting it somewhere. OK, that is enough thinking about this; let's not get down in the dumps with fascination about such things. Solutions are at hand, harmonious solutions. Believe.

Looking upward and outward for a new place to live for teeming humanity, let's creatively explore how to get there and where to live exactly, once there.

Chemically-fueled rocket propulsion transportation seems much too limited in this application, due to the enormous chemical energy needed to conventionally lift into space, per person. There are several billions of us needing to go, and soon, if we are to stop crushing our beloved planetary ecosystem. Most of the energy in chemical rocketry is used just to lift the fuel itself; relatively little of that fuel energy is used to lift payload itself. So let's look at the past for solutions, in light of today's technological advances.

Eliminating the fuel used just to lift most of the fuel, would make the process far more efficient. If thevehicle is already moving fast enough, say 18,000 mph, as it leaves earth surface, that would put it into orbit without lifting fuel just to lift fuel...if our atmosphere were notin the path, that is. Trying to punch its way through the air at 18,000 mph would consume its velocity and destroy it with the heat caused by shoving that much air aside

that fast. Like a meteor burning up. So...let's move the air aside first, out of the path. Move the vehicle through a tube which has had all the air pumped out of it, ahead of time.

A very long tube it would be, and surely very heavy altogether. How to hold it up? By converting our 18,000mph vehicle into a steady stream of vehicles, each of which drags upward a little on the tube as it rises toward space,the tube can be supported in the earth's gravity field. Shifting our thinking a little more, convert the vehicles into just a mass stream moving at the 18,000 mph within the vacuum inside of the tube, the mass stream supports the tube by giving up a small part of its velocity, its kinetic energy, as it flows through the tube. The tube then becomes a fixed structure, attached to the earth's surface on one end. This structure could be used to move vehicles along its outer surface, like an elevator does. A "space elevator".

The elevator cars on such an elevator could lift upward by electromagnetically dragging against the upward stream of mass within the tube. Low friction tracks, such as magnetic levitation tracks, would make the process more efficient. No fuel for this process is needed to be lifted.

The mass stream in the tube travels in a circuit, returning back and forth between earth surface and somewhere in space. Ideas are built on ideas; a version proposed by Keith Lofstrom would cycle from one point on earth surface upward, across some great distance, then return to surface, be reversed, go back along the route to the starting point, all in a continual flow. Expanding on this, Earle Smith proposed a continuous flow from one point on the earth, circling out to geophysical earth orbit (GEO), continuing on around the earth to return to the initial point on the earth, again

in a continuous stream. Rod Hyde proposed a version that would essentially go straight up; the stream would be reversed in direction at its upward end, returning down alongside the upward part of the stream, back to the starting point on earth, back and forth between earth and space.

All these versions are powered by electricity. The mass stream is pushed along by magnetic fields interacting between the stream and magnetic fields alongside the tube. Rod Hyde envisioned the stream as being composed by vast quantities of beryllium disks, each with a magnet attached. The stream would be powered by electricity, and a large version consuming as much electricity as a large city, would be able to lift all the billions of humans on the planet now, out into space in just two weeks' operating time. Hyde, Loftstrom and Smith presented these concepts in 1984. Their structures are very big and expensive, and untried. Putting such structures up seems a major undertaking with much risk, even worldwide. However, these structures have the potential of being able to move the bulk of humanity out into space. If they had somewhere to go, that is. It would take a lot of courage to put such structures up, it seems.

Getting back into the creative thought mode, let's continue on with the design. Where do the people go, in space? Well, there are limits to where these elevators can go, for they are essentially compression structures,depending on compressive force to hold them together. Thus, they would not be able to go beyond the geophysical orbit; in fact, Hyde's version depends upon earth gravity to reverse the flow back toward earth surface at its upward end, thus not able to reach GEO by itself. And anything getting off these elevators short of GEO would fall back to earth, fast, unless accelerated adequately first, as in Loftstrom's

Launch Loop versions. GEO, geosynchronous earth orbit, seems ideally suited for the upward terminal of such elevators, because GEO is stationary relative to the earth's surface. Thus one end of the elevator is on the earth, motionless; the upward end is stationary at GEO. Anywhere else would require relative orbital motion; the connection between elevator and upward orbital terminal then would become high-velocity, requiring complex energy exchanges as payload moves between them. At GEO, payload directly connects to the orbital terminal. Hyde's version of the space elevator might use a long tether balanced across GEO, the tether's downward end reaching the top ofthe elevator, so as to span the remaining distance to GEO.

Here at GEO we can build space colonies, space habitats or settlements. If we build the wheel-shaped Island One Stanford Torus space settlement design envisioned by NASA in1975 (ref. NASA SP-413,although for use at L-5 then), there is room for 1,475,000 of these wheels, if strung together like pearls on a necklace for mother earth, circling the earth above the equator, 5 earth radii above the planet's surface. In the Stanford Torus design, the wheel is over a mile in diameter, rotating so as to provide earth normal artificial gravity effects, and the wheel inner tube is 427 feet wide inside. Divided up into three sections of agriculture, alternated with 3 sections for human residence and light industry in closed ecosystems, this single ring of Stanford Torus wheel-like habitats around the earth would house up to 15 billion people, far more than the whole earth has now or possibly could accommodate well. Solar energy abounds up there, on the average seven times as much as arrives on an equal surface on the earth. Sunshine abundant for growing crops in the agricultural areas on the Stanford Torii, which in turn feed livestock and the human population.

It would be well for there to be many such elevators connecting earth to this GEO habitat ring, perhaps each nation would have at least one elevator. The initial Stanford Torii would be built from materials lifted up from the earth, along with the robotic machinery to continually build more of these habitats.

Once there are these space settlements up there, a few at least, with 10,000 people each, the picture of space will look different. Building spacecraft up there, it will be relatively easy to return to the moon, from where we will get most of the structural raw materials for most of the Stanford Torus habitats to be built in GEO. Trips out to get asteroids for more material would become as common place as airplanes now land and takeoff at airports. Water and other valuable chemicals might come from the moons of the outer planets, if we choose not to take the water from earth glaciers instead, to water the agricultural areas in the space habitats.

Electrical power to run the space habitats comes from solar power stations, designed in the '60's. The same technology might well be used alongside each of the space elevator structures, supplying power to operate the elevators, instead of using energy from earth. Indeed, the solar power satellites could put extra energy into accelerating the elevator mass streams in the downward direction, which could be drawn off from the stream's kinetic energy at the earth surface contact sites, to supply electrical power to power whatever human civilization remains on the planetary surface. However, hopefully humanity will be responsible enough to have people only on earth surface to restore the planetary ecology, and run vacation resorts for GEO ring residents.

This overall design of kinetically-supported space elevators linking a ring of space habitats located at

GEO, all powered by solar power station technology, and with transportation materials link from the ring to the moon and elsewhere in space, seems cohesive. Thus it is due further design work. To develop technology and get real-world experience with the dynamics of long space elevator-like structures, perhaps the concepts could be reduced to essences. For example, the mass stream perhaps could be glass fibers, with magnetic material embedded within the fiber at specific distances along it. These fibers could be electromagnetically accelerated within a fine tube, say 20 mils in diameter. The tube would be pumped free of air, and the fibers prevented from contact with the tube walls via electromagnetic fields along the tube. With a reflector of the steam of fibers at one end, the reflection process results in a tensile force; this force could provide lift energy for the end of the tube. As in the larger versions, some of the kinetic energy of the rising high-velocity mass stream of glass fibers would be used to support the tube along its length. Steering of the rising end could be accomplished by shifting the center-of-gravity of the reflector relative to the tube, providing off-balance lateral forces, resulting in a steering mechanism. The stream would be accelerated on the earth surface; coiled prior to raising, the volume of this example would be only be equivalent to a cube 50 feet on an edge, and the length still be able to reach almost to GEO. A longer version could emplace a seed elevator of the kind that loops from earth surface, out around to GEO at the opposite side of the earth, continuing to loop back to the starting site on earth surface. Bundles of such micro-diameter space elevators might be used to support very large elevator cars going to GEO, carrying materials, tools, and personnel to build the first space habitats there.

This design for an expanding human civilization located in near-earth (GEO) space, linked directly to the

earthsurface by kinetically-supported space elevator structures, powered by solar satellite power technology, and a healing of the earth's ecological system, would require only technology development, not major breakthroughs in science. The untested basic concepts of elevator transportation into space need to be demonstrated to the public eye, as well as catching the public awareness for presentation of such opportunities to take the ecological load off of mother earth while at the same time provide for a greatly expanding human civilization. Given the viability of this scenario, the implementation of it would remain the decision of a responsible humanity. If undertaken as a major effort (say, using half of what each nation now spends on defense preparations each year), this would become one of the great adventures of all time for the majority of humans now living on earth surface.

References: GEnie Spaceport Library, files # 690, 671, 655, 644, 634, 629, 592, 581, 573, 563, 553, and 475.
by James Edward David Cline ("Jed")
Van Nuys, California February 9, 1989

TreeHouse Haven text, published in Meditation Magazine in Winter 1990 issue

The first hardcopy formally published article on the subject was published in the Winter 1990 edition of Meditation Magazine; and the text of the article was also put on the Genie Spaceport Library. It was an appeal to people who had the ability to meditate, to dream of better futures, to help with bringing forth this concept into reality; it also took advantage of the author's position as a staff member of the all-volunteer magazine. Here is that file:

****
Number: 1077 Name: TREEHAVEN3
Address: J.E.D.CLINE1 Date: 891225
Approximate # of bytes: 16380
Number of Accesses: 14 Library: 3

Description: Refined popular magazine article which was not selected for publication, on KESTS and space habitats.

Keywords: KESTS,habitats

TREEHOUSE HAVEN II   by J. E. D. Cline

Changing mankind's relationship with the planet Earth may be necessary for the long-term survival of both. Here is a recently-conceived, yet-to-be-developed technology that may offer a key to that survival. It could make possible a huge expansion of civilization, while also enabling the restoration of planetary ecology to a nearly pre-mankind, primal state. It will take courage, innovation, and love on a planetwide scale, to actualize it quickly enough to save a great many species from extinction.

Analogous to the process of building a treehouse, its key is a possible way to create incredibly high structures which are not limited by the strength of materials used to build them. The structures are supported by an enormous amount of kinetic energy circulating within them. These structures could then support and power a form of railroad which directly connects a point on the earth's surface with the unique orbit that rotates exactly at the same rate as the earth's surface, where our TV and phone satellites are now located. At this upper terminal of this railroad, we can build lush and spacious habitats very earthlike. There is room in this orbit for spacious homes, farms, and

factories providing luxurious life for at least three times the present entire human population of the earth!

The scenario here is seemingly outrageous, but is it any more so than the thought of traveling around a spherical round world was to the flat-earth-consciousness contemporaries of Columbus? Is it any more fantastic than the thought of men walking on the moon was considered in 1960? Despite its outrageousness and fantastic appearance, it's tremendous potential for helping mankind's relationship with Earth's ecology makes it worthy of our consideration.

As a youth, it was fun building a treehouse: climbing the tree; friends helping each other haul the boards up into the tree; together figuring out how to place the boards among the tree limbs to build the treehouse. Once it was built, climbing up and looking down to the ground far below...experiencing a feeling of being in a safe haven, reaching instinctual roots in the mind. Remember the adventure? The feeling of accomplishing something worthwhile!

There is opportunity now for similar responsible creative adventure for all mankind. You are invited to participate. More than adventure, it appears to be a way of fulfilling our responsibility to both our planetary ecology and to our civilization.

Presently each week man's current population on th planet is piling up two million tons of garbage … putting it ...somewhere; causing the extinction of one more of our fellow lifeforms on this planet; and depleting forty more square miles of cropland. Just as a nine-month pregnancy unborn child in the womb, mankind has just about outgrown Mother Earth's environ's ability to contain and nurture, absorbing the resulting wastes.

The immense resources of sheer room, endless solar energy, and vast resources of raw materials on the moon and asteroids patiently await mankind to bring life to them, as they circle in our vast solar system

The treehouse urge ...to build a high haven...has often played its notes on the song of mankind. Surely our more primitive ancestors found sheltering refuge among the high treetops, safe from the large predators that hungrily roamed the ground. And thousands of years ago the ancient Babylonians actually attempted to build a tower so high that it would enable man to enter "the heavens", at a site now known as E-temen-an-ki.

More recently in the 1960's the concept of building a tower so tall that it would extend upward so far that the centrifugal force of the rotating planet would hold it up, conceived by Artsutanov, a Russian. However, the necessary strength of construction materials for conventional construction of such a tower far exceeds the strength anything known. The trunk of the tree isn't strong enough to grow that tall.

Then in the mid "80's, extraordinary forms of Earth-to space transportation structures were conceived here in the USA. These structures would be supported by the kinetic energy of high-velocity mass circulating in a loop within them, instead of depending on mere strength of materials for support. Rod Hyde's concept was a fountain-like dynamic structure which would go straight upward, using a stream of magnetic discs shooting up through an airless tube, bouncing off of a weight at its top, returning back down the tube to the ground where it would be turned around and propelled upward again, endlessly. Some of the energy of the magnetic disk mass stream would be used to support the tube and lift elevators up the outside of the tube. Rod estimated that

the tower would be able to lift the combined weight of every human being on earth, operating for just two weeks using the electric power that Los Angeles now uses.

Keith Loftstrom's concept used a continuous magnetic belt circulating in an arc from one ground point to another. The top of the arc would be above the Earth's atmosphere, and the two ground points might be on different continents.

Earle Smith continued development of the concept by proposing that Lofstrom's magnetic belt be placed to circulate around the whole planet, touchin the Earth surface at the lower end of the loop, and the high end reaching the orbit far above the opposite side of the earth which rotate at exactly the same rate as does the earth surface beneath it.

This unique orbit is known as GEO (Geosynchronous Earth Orbit), or the Clarke Belt, named after Arthur C. Clarke, scientist and author of many books and movies such as "2001 A Space Odessy". This orbit, 22,300 miles above the equator rotates exactly at the rate of the equator below it, so a satellite in this orbit will appear to be motionless to satellite antennas on the ground below. Here could be built a terminal for a railroad operating along the path proposed by Earle Smith.

Given a structure that connects the ground with this GEO orbit, carrying a railroad/elevator system capable of lifting every person on earth to GEO in two week's operating time, where would they go, once they got there? One possibility is to use a string of space habitats already designed in great detail, called "Island One", or "Stanford Torus", named after the college where the 1975 summer NASA workshop was held in

which it was designed. In GEO orbit there is room for at least one and a half million of these space habitats, and each habitat provides life for 10,000 people. That means room for fifteen billion people!

This "Stanford Torus" NASA space habitat design for 10,000 people would have a community area of 80,000 square yards, and an agricultural area of 650,000 square yards. The shell uses 156,000 tons of aluminum, and 48,000 tons of glass, all of which originally was to have come from the moon. Inside of the habitat, resembling the inside of a gigantic bicycle inner tube a mile across, there are 1 million square yards of dry soil, with 22,000 tons of water in it, supporting a biomass of 5,000 tons of plants, 900 tons of animals, and 600 tons of people, in a nearly closed ecology.

Spaciousness in the residential areas is achieved by terracing the housing structures up the curved walls inside the rotating habitat. Landscaped lawns, trees and flowers would abound. The wheel-like space habitat rotates providing artificial gravity withi it, and is divided up into 6 sections, 3 residential/light industry areas separated by 3 agricultural areas.

Current technological thinking has stopped short of combining these concepts. The linear-thinking mode of conventional science and technology has now to embrace holistic, whole-picture synthesis processes to advance further And that is where the envisioning mode of meditation can be effective Specifically, holistic picturing of the relationships of whole designs needs to be frequently applied in the creative-cognitive process, alternating and synchronizing with linear rational analysis.

Such a process was used to create the following scenario, while initially thinking about the need for economical mass transportation into space for true massive space colonization, so as to enable an ever-increasing human civilization while providing for the restoration of earth's ecosystem. Initially, analogous energy exchange relationships were focussed upon, then followed by the selection of corresponding physical forms necessary to implement them.

To build a treehouse haven, we must first have a suitable tree. We are going to have to grow the appropriate tree in this case, and the planting of the conceptual seeds is something you can help do right now, with your meditative envisioning as the concept grows in your mind, reading this Call this type of tree "KESTS", short for "Kinetic Energy Supported Transportation Structure" to help keep the basic principle in mind.

There are several basic forms of KESTS trees. One is like a flagpole, going straight up. One is like an arch, spanning one ground point across to another place on the ground. One is like an off-center circle around the earth, touching the earth at its lowest point, and touching GEO orbit at its highest point. Another is like a vine, writhing back and forth as it climbs, in response to the wind and other environs it finds as it goes up and carries payloads.

Just as a tree seedling, it first is energized by energy on the ground. Then when it is reaching high into the sky, above the atmosphere, it sprouts leaf-like solar power panels and other gatherers of solar energy so as to power its growth and life.

Eventually it will have a surplus of electrical energy, and that energy can travel back down the treetrunk,

analogous to tree sap in the wintertime, to nourishingly supply abundant electrical power for people's needs on the earth surface.

The strength of this kind of tree is provided by the continuous circulation of an immense amount of kinetic energy within the tree trunk. In more technical terms, it takes the form of a continuous stream of magnetic mass flowing at extremely fast speeds within an airless tube, continuously circulating between ground and GEO. It is moving so fast that it is actually in orbit around the earth, as it moves within the airless tubing. This stream is the lifeblood of the tree.

Other magnetic fields around the airless tube appropriately do such things as adding energy to the structure by speeding up the mass stream, bending the stream direction, and transferring energy from the stream to support the tube and power the railroad/elevators that run along its length. These magnetic fields form the specific shape of the tree, and provide resistance to bending from wind and the weight of whatever runs up and down the tree.

When the trees are grown, we start building the treehouse haven. From the top of these KESTS trees, imagine people building the first of a series of very large, hollow wheel-like structures. Each wheel is over a mile in diameter Inside it is about 600 feet wide, air filled, and lazily rotating just fast enough to feel much like earth's gravity The hollow wheel is composed of metal and windows that allow in sunlight reflected of of mirrors outside. Up here, where there is no day/night, nor clouds, seven times the sunlight reaches crops as compared to those on planet surface.

Divide the inside of each tube into six sections. Alternate sections are each occupied by an intensive

farm a half-mile long and 600 feet wide, slightly curved as if in mountain valley. There corn, wheat, rice, vegetables and citrus trees grow splendidly in the endless sunlight. Ponds hold a fish farm its water irrigating the crops. Chickens, rabbits, and a few cattle also thrive there.

In between those agricultural sections there are the home and light industry areas. These suburb sections resemble half-mile long valleys with homes and landscaping up and down the valley sides complete with lawns, trees, birds, and playgrounds. Pumps supply flow of water as in small stream in the park areas, where perhaps Koi goldfish brightly swim.

With this string of habitats already started high above Earth's surface, from KESTS of many nations to GEO orbit,we reach out to get the majority of construction raw materials from the moon's surface. A modified KESTS circles around the moon, connecting the moon's farside with the balance point between earth and moon known as L-1, from where reaction engines move the materials to GEO. By then, robot habitat factories are doing the work of building the 1.5 million habitats, making room for fifteen billion people and the agriculture to support them.

Each nation has access to the habitat ring, first moving excess population there, then others as the standard of living there exceeds that on earthsurface.. Each nation then restores its land to ecological balance.

Drawing to a close of our meditative envisioning process, declare mankind gaining sufficient responsibility and altruism to allow this new scenario to be an option. See the enormous new real estate it creates, being available to all at affordable prices,

eventually attracting most of humanit to its high standard of living. See the treehouse haven dwellers then responsibly and lovingly restoring mother earth's planetary ecology to a thriving balance. And perhaps most of all, let this whole picture of advancing civilization and ecological restoration be achieved and populated by people who have learned to live in peaceful an constructive action, wisdom and meditation.

Now that you have the picture in mind, realize that as your creative envisioning energy aligns with this revolutionary proposal it is affecting the waves of the planetary social unconscious, bringing it one step closer to manifestation, more accessible to the thinkers who can physically develop the required technology. And from a future Now, from the manifested ideal you have helped create, look out into space feeling a greater connectedness with the universe. Feel the sense of accomplishment in building your treehouse haven. Finally, look out at the beautiful planet, Mother Earth, revitalized and healed, having proudly given birth to her offspring, Humanity.

Biography: James Edward David Cline is a volunteer member of the staff of MEDITATION magazine..

The actual pages are shown next, as they appeared in the Winter 1990 edition of Meditation Magazine. This was an envisionary magazine instead of a technical magazine; but it was an effort to get the concept into people's awareness as being one of their options to enable their thriving into the future.

We can be mindful of the urgency of the immediate problems, economic, sociological, ecological, etc. confronting us here and now on the face of our planet. We can be aware of the need to choose and act along what are judged to be the most practical and efficient lines. Let us as well acknowledge the visions that take us beyond and into alternative creations of existence — where the world confidently knows itself as new.

Treehouse Haven

J.E.D. Cline


Dave Cline

Changing mankind's relationship with the planet may be necessary for the long-term survival of both. Here is a recently conceived, yet-to-be-developed technology that may offer a key. It could make possible a huge expansion of civilization, while enabling the restoration of planetary ecology to a nearly pre-mankind, primal state. The scenario presented is seemingly outrageous, but is it any more so than a round world was to the contemporaries of Columbus? Is it any more fantastic than the thought of walking on the moon might have been in 1800? Nevertheless, its tremendous potential for helping mankind's relationship with Earth's ecology makes this proposal worthy of consideration.

As a youth, it was fun building a tree house: climbing the tree, friends helping each other haul the boards up into the tree, together figuring out how to place the pieces among the tree limbs to build the tree house. Once it was built, climbing up and looking down to the ground far below . . . experiencing a feeling of being in a safe haven reaching instinctual roots in the mind. Remember the adventure? The feeling of accomplishing something worthwhile. Now, as an adult, an analogous opportunity arises. A chance for everyone to share in its actualization is given in the meditative process in the last part of this article.

Let us explore paths leading to the vision of a safe haven for humanity, atop tree-like KESTS (Kinetic Energy Supported Transport Structures), rooted in the Earth, and extending so high they would reach our telephone and TV relay satellites. The "leaves" of the trees are solar power satellites, supplying power independent of any earth resources. Atop the KESTS is a vast network of space habitats ranging over the whole globe, with room enough for all mankind three times over, taking its great load off of Mother Earth. With civilization moved into space, yet attached directly to the earth surface, our planet can be restored to a balanced global ecology again, like a planet-wide national park.

The linear thinking mode of conventional science must now embrace holistic, whole-picture synthesis to advance further.

Let me show you this exciting picture of an extension of Mother Earth. The picture is of Earth surface connections, rising and extending upwards along KESTS, like spokes of a wheel. These extensions join up, at an altitude of 22,300 miles, with GEO (Geosynchronous Earth Orbit) where vast space habitations encircle the Earth. This extension of Earth's surface would allow the major worldwide civilizations to move off the planetary surface. The Earth surface ecology could then be restored to thriving health. Civilization would be also, with a huge increase of living space and easier access to the enormous resources of our solar system.

Picture it something like a bicycle wheel, where the rim is made up of the GEO space habitats, the spokes are the KESTS (the rising transportation structures), and the hub is Earth itself.

More than adventure, it appears to be a way of fulfilling our responsibility to both our planetary ecology and to our civilization. For example, each week mankind's current worldwide population is piling up two million more tons of garbage, causing the extinction forever of more of our fellow life forms on this planet, and depleting forty more square miles of cropland. It is as if Mother Earth is very pregnant with mankind. Just as a nine month unborn child in the womb, mankind has just about outgrown the environ's ability to contain and nurture, and then absorb the resulting wastes. The immense resources of sheer room, endless solar energy, and vast resources of raw materials on the moons and asteroids patiently await mankind to bring life to them, as they circle in our vast solar system.

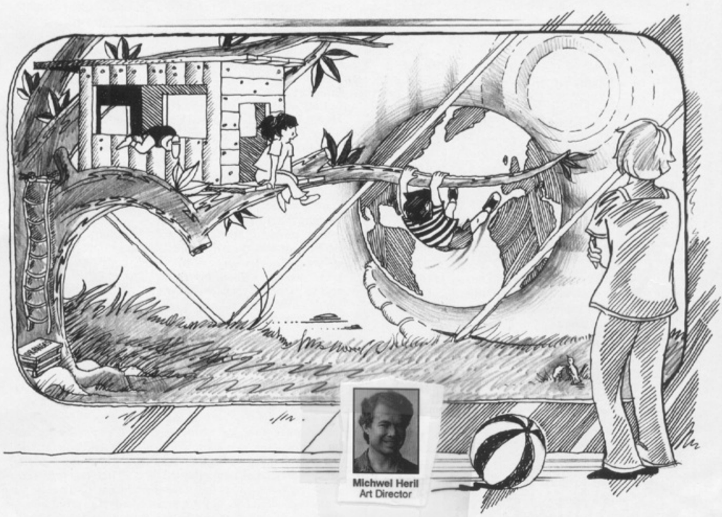
The tree house urge — to build a high haven — has often played its notes on the song of mankind. The "Tower of Babel" is an example. Thousands of years ago the ancient Babylonians attempted "to build a tower so high that it would enable man to enter the heavens." The physical remains of this ziggurat exist at a site known as E-Tamen-an-ki. It was written that the "gods did not want man loose in the heavens," and so con-

founded the builders that they could not understand each other's speech, and thus could not continue the project together. Yet even then, seeking a better life for all, there was the urge to use the unique constructive talents of mankind to build a means to reach a place of great resources that was safe from the predators that roamed the land.

In the 1960's a Russian by the name of Artsutanov conceived of building a tower so tall that it would extend out past even GEO. So high that the centrifugal force of the rotating earth swinging the tower around would hold it up! Many others since then have re-invented this concept for efficiently moving between Earth's surface and space, only to dismally discover that the necessary strength of construction materials far exceeds anything known to man. The trunk of the tree isn't strong enough to grow that tall. So it looked as if rocket propulsion was the only way to get from earth to space. But chemical rockets, as are used today, are far too inefficient for the kind of exodus necessary to take the burden off of the earth environment. Most of their fuel energy is used to lift the weight of the fuel itself. At a current cost of $3,000 dollars a pound, a 160 pound person's fare would be $480,000 to GEO, using conventional technology like the space shuttle.

In a summer workshop in 1975, NASA designed a space settlement of 10,000 people to be located at the distance of the moon. This space habitat was designed in great detail. For example, it would have a community area of 80,000 square meters, and an agricultural area of 650,000 square meters. (A meter is about the length of a yardstick). The shell uses 156,000 tons of aluminum, and 48,000 tons of glass, all of which could come from the moon. Inside, there are 1 million square meters of dry soil, with 22,000 tons of water for it; the biomass of people is 600 tons, animals 900 tons, and plants 5,000 tons, in a nearly closed ecology. Due to the increased sunlight for crops, the increased productivity factor of cucumber is 8.5, of eggplant 12.6, of lettuce 2.3, and of tomato 2.3. Spaciousness is achieved by terracing the housing structures up the curved walls inside the rotating habitat. Landscaped lawns, trees and flowers would abound. If this design were integrated with the tree house scenario proposed here, one-and-a-half million habitats would be strung together like necklace beads circling Earth synchronously with the surface 22,300 miles below.

Although conventional rocket-propelled space transportation now requires thousands of dollars per pound, the actual energy needed to lift an average sized human being from the surface and beyond Earth's gravity is only about a thousand kilowatt hours, as once pointed out by the author of *2001: A Space Odyssey*, Arthur C. Clarke. Thus an electrical elevator would use less than $100 (instead of the previously mentioned $480,000) of electricity to lift each person to space. The structure of such an elevator would require material strengths far



Michwel Herll
Art Director

greater than are now even thinkable. However, new structural principles have already germinated in the mind of creative mankind.

In the mid '80's Rod Hyde and Keith Lofstrom conceived extraordinary forms of Earth-to-space transportation structures. They would be supported by the kinetic energy of high-velocity mass travelling within them in a loop, instead of by the mere strength of structural materials.

Hyde's fountain-like dynamic structure goes straight up and down, using a stream of magnetic discs, magnetically flung up inside an evacuated tube. Some of the energy of those speeding magnets would be used to support the weight of the tube. At the top of the structure, the discs would be magnetically bounced and returned back down the tube to the ground to again be flung up the tube, continuously supporting it. The evacuated tube is necessary because air would slow down and burn up those very fast discs. But this method used by itself will not be able to reach GEO, because at GEO there is no weight-force to bounce the stream of disks back toward the ground.

Lofstrom's concept used a continuous flexible iron belt to be electrically flung up and across an entire continent just above the atmosphere at an altitude of perhaps ninety miles. Picture a pair of pulleys connected by a flexible belt, one pulley located somewhere on the east coast, and the other pulley located on the western coast of Europe, with a very long belt rising, arched between these two points. Upon returning to Earth's surface, the belt would reverse its direction, thereby forming a continuous loop.

One problem these concepts present: any object disembarking either of these dynamic structures would just fall back to Earth, if not rocket boosted enough to orbit on its own. So these structures would be merely carriers for conventional rocket-propelled vehicles. The overall transportation process would be more efficient, but perhaps not worth the effort and the considerable risk these immense structures would represent.

Earle Smith proposed extending Lofstrom's iron belt to circle above the earth, touching Earth's surface at one point and then continuing all the way up to GEO, above the opposite side of Earth, then circling on around to the surface again. At GEO, an object disembarking from the elevator could stay put, rather than fall back to the surface. However, this belt lacked a way of supporting the weight of its protective housing on the downward direction. The iron belt would be stretched too severely in parts of its trajectory, risking breakage. Plus the process of building it in collapsed form all the way around the Earth on the surface, and then speeding it up to raise it, seemed an incredibly difficult undertaking. But a transportation structure supported by the energy contained within it and reaching to GEO, remained a key idea fundamental to the tree house haven concept.

One may ask "What is so special about GEO?" It happens to be the distance from Earth's surface (22,300 miles) where the speed necessary to stay in orbit is exactly the same speed at which Earth's surface rotates. The orbit there takes twenty-four hours to go once around Earth. An object in GEO appears to not be moving, as seen by one on the ground. Beyond GEO, an object appears to orbit slower than Earth, as does the Moon. Beneath GEO, an object appears to orbit faster than Earth, such as the space shuttle. Find a satellite dish in your neighborhood. Its focus is aimed at a point on GEO, where the TV relay satellite sits, apparently motionless

as far as the satellite dish is concerned. An elevator exit door could just as well be there.

This is where the edge of technological thinking has stopped. The linear-thinking mode of conventional science and technology must now embrace holistic, whole-picture synthesis processes to advance further. And that is where the envisioning mode of meditation can be effective. Right-brained holistic picturing of the relationships of whole designs need to be frequently applied in the creative-cognitive process, alternating and synchronizing with the left-brained linear rational analysis.

Please join me as I guide you through a picture of what I believe to be a viable alternative to end many of the world's current problems. In building a tree house, first we must grow the tree. As I describe the theory of KESTS, grow the concept in your mind.

Imagine flinging something solid upward. Watch it coast far up then slowing down and dropping back. Imagine yourself so powerful that you throw the object far above the earth's atmosphere. Now let an electric motor do the throwing; rest your own muscles. In order to eliminate the resistance from air friction, the next time the object is flung upward, let it fly through a tube that keeps the air out of the path of the object. Let the object drag slightly on the inner walls of the tube as it rises, supporting the weight of the tube.

Now imagine the object having magnets on it, and let the electric motor and tube touch the object only by way of magnetic fields, eliminating physical drag. Fling a steady stream of these objects upward, inside the tube, reaching high into the sky.

From the outside you see only a tube reaching up from the ground, far into the sky. Just as the weight of the tube is supported by the energy of the stream of magnetized objects, so can it support the weight of objects on the outside of the tube, like elevators or train cars on non-friction magnetized tracks. Let the dynamics be so that a great many people and construction materials can ride up to GEO.

Imagine those people building the first of a series of very large, hollow inner tube-like structures. Each inner tube is over a mile in diameter. It is about 500 feet wide, air-filled, and lazily rotating just enough for it to feel like earth's gravity. The tube is composed of metal and windows that allow in reflected sunlight. Up here, where there is no day/night or clouds, sunlight reaches every square foot.

Divide the inside of each tube hollow into six equal sections. Alternate sections are each occupied by an intensive farm a half-mile long and 500 feet wide, slightly curved, as in a mountain valley. There corn, wheat, rice, vegetables and citrus trees grow splendidly in the endless sunlight. Ponds hold fish farms, their water irrigating the crops. Chickens, rabbits, a few cattle also thrive there.

In between those agricultural sections there are the homes and light industry areas. These three suburb sections resemble half-mile long valleys with homes and landscaping up and down the valley sides complete with lawn, trees, birds and playgrounds. Pumps supply a flow of water in small streams in the park areas, where Koi goldfish brightly swim.

With this string of inner tubes already started high above the Earth's surface, standard space technology can reach our moon to obtain the raw materials for continued building. A flow of raw materials moves from the moon to GEO for the construction of the remaining line of inner tube habitats all the way around Earth. Since there is room for one and a half million of them and each one comfortably houses and supports 10,000 people, there is space for up to 15 billion people — triple the whole Earth's current population.

These space habitats are designed to be nearly closed ecological units, so everything is designed with 100% recycling in mind. Some of the resulting recycling methods may be useful for the few people who choose to remain on Earth's surface as caretakers.

Every nation has access to the habitats. First the excess populations resettle, then others as the quality of life improves. Each nation then has the opportunity to begin the restoration of its Earth land back to ecological balance, eventually allowing the entire Earth to become one gigantic international park area (Eden regained?) where a great abundance of living species can again thrive.

Drawing to the close of our meditative process, declare mankind gaining sufficient responsibility and altruism to allow this new scenario of KESTS and GEO tree houses to be a viable option. See the enormous new real estate it creates, being available to all for an affordable price, eventually attracting the majority of mankind to its high standard of living. See the tree house dwellers then responsibly and lovingly restoring the planetary ecology to a thriving balance. Going down to Earth surface on a KESTS is like going on a vacation camping trip, taking time out to admire the beauty of nature. And perhaps most of all, let this whole picture of advancing civilization (while restoring planetary health) be achieved and populated by people who have learned to live harmony with nature.

Now that you have the picture in your mind, set down this magazine and include your own creative visualizations in your meditation. Realize that as your creative energy aligns with this revolutionary proposal it is affecting the waves of the planetary social unconscious, bringing it one step closer to manifestation, more accessible to the thinkers who can develop the technology required.

Thank you for your help towards making possible this alternate path for restoring our planet. Meditative, active envisioning is the first step in creating anything. In participating in this creative process what does your inner Wiser Self tell you? Are the goals of the "Tower of Babel," a tower so tall as to enable people to enter the heavens, now within the reach of mankind's ability to peaceably manifest? Look to the Heavens Within. Know that meditation, envisioning with emotional feeling, can tip the scales of Causative Formation in either direction (from the here-and-now).

In a future now, from the manifested ideal you have helped create, look out into space feeling a greater connectedness with the universe. Feel the sense of accomplishment in building your cosmic tree house. Finally, look out at the beautiful planet, Mother Earth, revitalized and healed, having given birth to her child, humanity.

J. E. D. (Dave) Cline is active in the risky combining of metaphysics/meditation with science/technology, with the objective to improve the quality of life for all. Dave is member of our staff and a newly ordained metaphysical minister through the University of Metaphysics in Los Angeles. He earns his living mostly in electronics development work, and has contributed twenty-two articles on space transportation and colonization in the GEnie Spaceport Library, available worldwide to people with home computers and modem. this article is based upon Treehousefive, copyright (C) 1989 by GEnie, SPACEPORT UNLIMITED, and J.E.D. Cline. For additional information on Treehousefive, write Dave Cline c./o Meditation magazine, 6801 Lindley Ave. Reseda, CA 91335.

Long Space Transportation Structures talk given to LA chapter ISSS in 1994

ISSS = International Society for the Systems Sciences

A POTENTIAL APPLICATION OF GENERAL SYSTEMS THEORY

KESTS: A UNIQUE TRANSPORTATION TECHNOLOGY CONCEPT & IMPLICATIONS

by J. E. D. "Dave" Cline

As presented to the L. A. Chapter of ISSS on November 9, 1994

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Urgency to provide people with hope that vast new resourceful living space will be available in their lifetimes, so as to stop the burning of the rainforests etc. A dual approach is presented, to be done at same time, one economically and quickly puts a real space colony in low earth orbit to verify its basic tenets; the other is to develop the technology of kinetically-supported extremely long structures, which has the potential to reach from earth surface even beyond LEO to GEO, where its massive payload capability can be used to build and supply a vast group of large space colonies.

Described here is an exercise application of General Systems Theory which might prove out to be a large and significant project. Several aspects are discussed: the need to review the fundamental concept of

"transportation"; the theory and application of "kinetic energy supported transportation structures", including an integrated earth-surface-to-Clarke Belt truely massive transportation capacity bridge system; an example of a creative process for building a mental model; an overview of high efficiency lunar-surface-to-earth orbit transportation concepts; and a relatively quick and economical way to build a mile-diameter space colony research habitat in low earth orbit using modified Spacelab & Space Shuttle technologies.

GENERAL SYSTEMS THEORY APPLICATION: AT THE BEGINNING OF SYSTEM DESIGN

Instead of applying general systems concepts to understand and reconfigure existing systems for more efficient and appropriate function, the systems concepts could be applied to explore The potentials of various configurations of a proposed technology. This opportunity could condense the trial-&-error stages of its development, adding a special wisdom to the progress of creation of a technological system that has the potential of enabling a much greater well-being of both human civilization and the Earth's ecosystem.

Aspects include the interaction of a given potential technology with the technology with human physiological/emotional/cognitive/ imaginative systems, social systems, economic systems, industrial systems, technological scenario systems, religious & political systems, resource management systems, agricultural systems, health & well-being systems, environmental balance systems... even individual/group belief systems. The subject application for general systems theories offers the opportunity to explore all of these aspects of a transportation technology that potentially could blossom into a vast near-space colonization

system in the near future.

TRANSPORTATION IN GENERAL: OVER LAND, SEA, AIR AND SPACE

Transportation systems define the circulation of goods, materials and people within a civilization. Increasing and maintaining transportation systems thus provide the opportunity for expansion and reliability of circulation within near-future civilization.

Transportation systems historically have advanced somewhat haphazardly, with a new technology being proposed, then developed, then manifested as an effect of corporate power struggles and profit making's dance with the potential user's needs. Perhaps it would be valuable to research the entire concept of transportation, and envision effects of other forms of transportation systems.

Some such concepts might include those using such technologies as skateboards, pantographic walk amplifiers, interconnecting swinging cables from pylons, high speed metal/fiberglass bands distributing power to slide-grabbers alongside roadpaths, and kinetic energy supported transportation structures.

Each of these would provide new opportunities to civilization, from high efficiency city commute systems to earth/space transportation systems. All of these concepts have roots in the past, yet were passed by at the time due to lack of supporting technology or lack of motivation by corporate manifestation structures. The need for vastly more efficient human commute systems is evident in the face of limited fossil fuels and increasing use of automobiles in developing countries. The needs of an expanding population for long distance efficient transportation systems would alleviate much of

the need to convert farm land into residential land, thus preserving the food supply.

The ground commute transportation systems concepts are overdue in development, and could, for example, interface the LA Metrorail system to individual user's homes and places of employment, and probably would then go on to also function in the long-range high-speed pathways between cities and countries. The intense rivalry among existing industrial technological corporations for large but finite municipal funds, in somewhat desperate economical times, suggests that this field be bypassed for now to avoid the risk of being considered unwelcome competition by powerful corporate rivalrous economic interests, short-sighted as they are.

However, considering the needs of the entire planet, this paper will focus on the possible use of General Systems Theory on a different highly speculative technology with tremendous potential for benefit to human civilization and the planet's ecosystem.

A TRANSPORTATION TECHNOLOGY POTENTIALLY BRIDGING EARTH AND NEAR SPACE

This contemplated technology would have many inherently integrated functions, making it especially useful as a testing ground for general systems concepts. And the implications for new opportunities for mankind encompass nearly every aspect of human endeavor, which are then more potential applications of the wisdom of general systems theories. The technology's physical development so far is nearly zero, and its potential difficulties are unusual, although there are abundant related analogous physical examples in existence; this offers the situation of optimum timing for imaginative, intellectual integration.

THE KEY TRANSPORTATION TECHNOLOGY CONCEPT

The key concept is that of creating a transportation technology which integrates the associated energy distribution with the structural form with specific sites of implementation. Stored energy within a structure (stored as kinetic energy, not as stress) has the potential for increasing the strength of a bridge structure as well as for distributing the energy used to power the vehicles traveling upon the structure. The kinetic energy of the mass of a continuous stream of objects moving at slightly above orbital velocities within extremely long evacuated loop pairs would be used to support the tubing within which the mass stream travels, and thus support the vehicles traveling upon that tubing. The kinetic energy of the mass stream would also be tapped by those payload vehicles throughout the range of the bridge structure.

The distances such a stored-energy-supported bridge could span are far greater than bridge structures limited by strength of conventional materials. Imagination can conceive of them not only connecting across wide rivers, but also across oceans, even to heights beyond Earth's atmosphere even out to the altitude of synchronous rotation with the equator's angular velocity.

SYSTEM OF MASSIVE PAYLOAD MOVEMENT BETWEEN EARTH AND THE CLARKE BELT:

The latter destination site is of special significance, because there in the "Clarke Belt" or geosynchronous orbit, truly massive space colonies could be built, with massive efficient direct access to both earth surface resources and of near-space resources such as the Moon's surface and of near-earth asteroids. With these

combined resources, there is room for a massively expanding human civilization which takes the environmental load off of "Mother Earth", allowing her restoration toward environmental balanced diversity, reversing the current strong opposite destructive trends.

The highly conjectural, unproven nature of this concept, seems balanced by its potentials for beneficial application, worthy of the exercise of application of general systems theories. And if the technology does become viable through R & D, the guidance of systems theories could greatly accelerate useful development and implementation for solution of some of mankind's most pressing problems of an expanding population in an enclosed ecosystem.

SYSTEMS FOR QUICKLY RAISING AVERAGE HUMAN COMPETANCY FOR THE TASK:

The associated step-function in improvement of human competency required for creation and conservation of the vast new resources accessed by the technology, is similarly an opportunity for application of general systems theories, focusing on the human element in this case. The basis of this step-function in competency already exists in fragmental forms, such as those body-mind goal-oriented kinesiology balances developed by the Educational Kinesiology Foundation. Other new kinds of educational techniques are represented by the Zygon stereo-acoustic flashing light pattern integrated audio instruction "Learning Machine" technology, and the Brain-Mind Research brain-wave pattern induction by stereo acoustic fields to the ears and body itself. Such learning-technologies integrate much of the whole human being, using specific goals chosen by the individual, goals of increasing competency toward achievements and goals for cleared emotional aspects

of the individual's life experiences. Such improvements in human balanced competency would be needed to implement and maintain the highly complex and powerful living systems potentially resulting from application of the subject potentially civilization-changing technologies.

So the application of general systems theories could simultaneously go to the key kinetic structure transportation technology, to the resulting changes to civilization's resources, and to increasing free individual human competency for expanding and maintaining the well-being of humanity, and to the resulting effectively enlarged Earth ecosystem. Further application could range to include the factors of supportively involving the current social power structures of corporations, societies and governments, each of which would interact with such wide-ranging forces of change, much preferably in harmonious ways. General systems theories might also be applicable in managing the experience of apparent technological obstacles which are encountered by any emerging technology. This could be an enjoyable, stimulating exercise.

MODELING THE GUIDED EVOLUTION OF THE APPLIED TECHNOLOGY

The thought here is that General Systems Theory could provide wisdom to the guidance of development and application of the proposed technology. Through modeling the overall system with its rich variety of subsystems, and exploring the internal/external environmental interactions between those systems, a basis for greater wisdom could result in the intelligent management of those systems. The effect of any proposed change to a subsystem could be observed as it reverberated amongst the sub- and supra-systems, in model form instead of empirical form.

THE KEY CENTRAL TRANSPORTATION TECHNOLOGY OF KINETIC STRUCTURES:

The viability of the kinetic transportation structure concept is key to the viability of all the following potential scenarios, although once up and running they would simply become the workhorses of more challenging and interesting tasks. So the subsystem of development of the kinetic structure technology will be considered first.

Would it work? Could it be built? Could it be installed in place? Would it be reliable? Would it adequately dampen oscillations generated by transient shocks? Would it have the required multi-billion pound capacity per year? Would it cope adequately with earthsurface movements and atmospheric storms? Would it interface stably with the earth-girdling ring of proposed space habitats in geosynchronous earth orbit? Would it cope with other speedy objects in space? Could living payload be adequately shielded from the pulsating magnetic ELF fields (which eventually could induce leukemia and Alzheimer's disease) produced by the pulsating magnetic fields along its length, especially at acceleration areas? Would it shake, writhe and wobble until it broke? Can it be supported while it is essentially like a bridge being built clear around the world? Could it do the job and survive the hazards of time? These are some of the kinds of questions which the kinetic structure transportation technology subsystem model needs to approach.

THE NEED TO BUILD AN IMAGINARY, MENTAL MODEL OF THE SYSTEM

To get started in solving these questions, one needs an adequate mental model of the whole subsystem, from which to more easily gain the necessary insights to

produce other forms of models such as mathematical and geometrical models. So now let's take a look at this strange proposed transportation technology which has such unusual qualities.

GENERAL PRINCIPLES: ENVISIONING STRUCTURES HARNESSING KINETIC ENERGY

To build an illustrative mental imaginary model of a kinetic structure, first picture the common water fountain arch, as an archetypical model to begin the exploration. Just paint the following images into your mind, adjusting and adding the composite mental painting model without yet criticizing, so as to get the whole model built. There will be plenty of time later for criticism, modification, and expansion. The task now is for you to first build the whole mental model without stubbing your mental toe along the way.

A. To conceptualize a kinetic structure in your mind, mentally picture the graceful arch formed by a decorative water fountain, the shape of a speeding mass stream of water in free-fall racing across a gravitational field.

B. Allow something to float on the top of this water fountain arch at the balance point, representative of an auxiliary rigid mass weight to be supported by the water fountain arch, slightly deflecting the water stream downward there, enough to support that weight.

C. Spread the supported rigid material's weight down along the rising half of the water stream arch, making it into the form of a tube that is supported by a slight drag and deflection of the upward-moving mass's fluid stream.

D. At the far receiving end of the water arch, turn the

water around and squirt it back upward into another similar water fountain arch, right alongside the first arch.

E. Enclose this second arch with a tube along its upward half, supported again by the drag and downward deflection of the enclosed speeding upward water jet stream.

F. Laterally connect the two streams' tubes so as to support the downward half of each water stream arch by the upward stream of its companion arch.

G. Embed magnets within this recirculating mass stream, such that magnetic fields extend usefully beyond the enclosing tubing, generating a pulsating magnetic field along the tubing's surface.

H. Let this pulsating magnetic field induce push-pull propulsive energy into payload vehicles moving along the outside of the tubing.

I. Let the pulsating magnetic field couple supportive energy into the tubing itself, through inducing opposing magnetic fields in the tubing, so that the internal mass stream does not physically touch the mass stream moving within it even though it supports it by magnetic fields.

J. Change the composition of the mass stream from water into a non-volatile substance. Evacuate all volatiles including air from the tubing, so that the mass stream moves within a frictionless vacuum.

K. At the bottom end points of each arch, where the mass stream is turned around, re-accelerated, and fed into the companion arch's upward end, let the accelerator now be electromagnetic, acting on the

magnets within the mass stream.

L. Speed up the mass stream so that it is going faster and faster, making the arch higher and wider, fast enough to reach beyond the earth's atmosphere and spanning between continents.

M. Continue speeding the mass stream and widening the arch until it goes from one side of the planet to the other side, then 3/4 of the way around the earth ... then further until it has completely circled around the planetary sphere to back where it started from...then interconnect the two end points together so as to form a pair of laterally-coupled continuous tubes touching the earthsurface at one end, and reaching far into space on the highest point far above the far side of the planet.

N. Continue speeding up the mass stream and lengthening the loop pair until the upward point is at the geosynchronous orbital altitude.

O. Build solar power satellites partway down from GEO along the loop, and use its solar-electrical energy to synchronously accelerate the magnets in the downward-moving side of the pair of mass streams, to make up for the energy that is used up to support the structure... the upward thrust from this acceleration supports the weight of the solar power satellites.

P. Have vehicles carry construction materials up the tubing bridge from the ground to GEO, where the material is used to build spinning artificial gravity space habitats.

Q. Make the kinetic structure big enough to carry the weight of structural materials enough to build a space habitat resembling the 10,000-person Island-One design.

R. Build several of these habitats side by side in GEO at the top end of the kinetic bridge structure.

S. Build more kinetic bridge structures starting at other points along the equator, and build more Island-One 10,000-person space habitats with their agricultural systems within them.

T. From this GEO Clarke Belt high vantage point, build spacecraft to return to the Moon, and build mining and materials processing plants on the lunar surface.

U. Create a transportation system from the Moon's surface to Earth's GEO Clarke Belt.

V. Build robots to build MANY more 10,000-person space habitats in the Clarke Belt, eventually enough to completely circle the earth, 1.5 million of them.

W. Build the space habitats to feel and look as much like earthsurface environments as possible.

X. Invite the earthsurface's expanding population to come live in the Clarke Belt space habit ring...there is room for 15 billion people already. Build more adjacent rings of space habitats. Go get water and hydrocarbons from comets, asteroids and the outer planets. Go for the Big Time as a spacefaring society!

"KESTS", A KINETIC BRIDGE STRUCTURE, IS...

A kinetic structure, as referred to in this document, basically is a compression bridge structure that inherently carries the energy which supports itself, and also powers vehicles along its outside surface. In general, a Kinetic Structure would maintain its shape against forces acting against itself by using the kinetic energy of rapidly moving mass within itself to resist

those forces. The mass stream's intrinsic path is maintained by automatically re-optimizing the velocity of each of the elements at thrust points along it's path. Energy coupling to these elements is electromagnetic, except chemical propulsion perhaps can be used during the initial massive distributed energy input during erection of the structure.

PICTURING GENERAL SHAPES OF KINETIC STRUCTURES

The direction of motion of the rapidly moving masses determines the forces which determine the shape of such a structure. A static shape is created by the balance of these internal kinetic energy forces with externally applied forces.

One common example of a static kinetic structure is that of an inflated balloon, which maintains its shape by using the energy of the rapidly moving mass of the gas molecules within itself. It tends to be spherical in shape due to the random omnidirectional moving masses within itself. Lining up the moving masses so as to all go the same direction, forming a narrow stream approximating ballistic trajectories at orbital velocities, we begin to see potential for traversing great distances, even upward beyond the atmosphere and back.

If a long piece of string has its ends tied together, it can lie crumpled in a heap on the table. However, if it is picked up and then somehow vigorously spun around its own virtual center, it would tend to stretch out into the shape of a rotating circle by the action of the circulating form of its kinetic energy.

This long, thin shape lends itself to the formation of bridges, which would balance the force of gravity on the structure and its carried loads by using the force of

balancing deflection of the upward-moving mass of the rapidly moving mass stream within the structure of the bridge. Arranging the mass elements to all move along the same direction with each other, a mass stream is formed. Instead of the spherical balloon structure, the mass stream forms a long relatively thin structural shape.

DYNAMICS INVOLVING THE KINETIC STRUCTURE

Consider the long thin path of a stream of mass elements moving at orbital velocities which are electromagnetically coupling their energy weakly to their surroundings. This electromagnetic coupling of energy allows their guidance and acceleration/ deceleration. Deceleration energy exchange provides a mechanism for supporting vehicle trackways along its path, coupling energy to propel vehicles along those trackways, supporting the weight of surrounding evacuated tubing along atmospheric portions of the path, and resisting deflection by external lateral forces.

If an external load is applied at some point against that mass stream, it would find itself resisted due to its deflection of the direction of the mass stream at that point. A small portion of the kinetic energy of the elements of the rapidly moving mass stream is used up in that resisting mechanism. If the circulating system has the ability to restore the original position and velocity of the elements of the mass stream, such as at the two endpoints of a parabolic arch spanning some area, then it has the ability to maintain its structural integrity against such external forces. Such forces could be the weight of evacuated tubing surrounding the path of the parabolic arch, payloads moving along it, and wind loads. For balance, the path of the stream needs to be like a highway, supporting equivalent traffic

flow in both directions along side-by-side lanes. This is necessary both to cancel out the longitudinal component of external loads applied at a point, and also needed because in an arch against the pull of gravity, only the upward-moving stream can support loads.

(There is an exception to this. If the external load supplies energy to actually accelerate the downward mass elements even faster downward, it would produce an upward supporting force on the external load. An example of this is in supporting the weight of a solar electric powerplant located on the side of the arch. Such a powerplant would increase the energy stored in the rapidly moving mass stream; the additional energy could then be extracted elsewhere along the stream, thus also providing the function of a power transmission line.)

KINETIC ELEMENTS OF THE MASS STREAM

The design of the mass stream elements needs fit several criteria. First, they need to contain a permanent magnetic field source, because this is what generates the current in coils which it passes through so as to yield energy, and is also the field which is thrust against when the mass element is being re-accelerated and guided. Probably several sets of permanent magnetic field sources will be needed so as to more easily define its position and velocity when it is being course and velocity corrections by the earth surface accelerators. Second, they need to be able to withstand physical contact with other elements in the mass stream; probably there will be a periodic wear parameter observed, and those exceeding specs would be culled from the stream and replaced with refurbished ones. Third, there are different types of mass elements. Most are simply kinetic energy quanta; others serve

specialized functions such as carrying small specialized payloads material within themselves and others being payload on a one way trip to be raw material for structural components.

PLANETARY BODY ACCESS STRUCTURAL SHAPES

Besides the vertical loop and the parabolic arch shapes, there is another basic form. If the mass stream is sufficiently large as to extend upward at an angle from some point on the earth's surface, it could continue on to be gradually bent by the earth's gravitational field to circle the earth to return to its point of origin, such as from a point on the equator circling around the earth back to itself. All the way around the Earth, extending far out into space on the opposite side of the planet from its surface contact central point. Non-equatorial surface contact points might might be possible needing a mirroring point on the opposite side of the equator from itself.

APPLICATIONS OF PLANETARY BODY ACCESS KINETIC STRUCTURES

Such large kinetic structures could provide transportation capability millions of times greater than what we currently have. This massive capacity would totally change mankind's relationship with space. The experience of building and utilizing a Stanford Torus space settlement in the Clarke Belt, constructed entirely of resources from the earth surface, could teach us a lot which would help in the design of more of the settlements, as well as learn technological and sociological techniques useful on Earth herself. The first space settlements in the Clarke Belt, permanently connected to earth surface by the kinetic structures, create a beachhead for returning the the Moon, this time to create the industrial resource base for building

the main structure of vast numbers of those settlements in the Clarke Belt. For example, building just one continuous string of Island-One type 10,000 residents each stanford torus space settlements all the way around the earth-circling Clark Belt, would provide residential areas and supporting agricultural areas for up to 15 billion people. This would enable a vastly expanding human civilization while taking their load off of Mother Earth.

EMPLACING KINETIC TRANSPORTATION STRUCTURES BETWEEN EARTH AND SPACE

Putting these immense structures into place would require technological expertise even greater than needed to create the bridges themselves, much as the caissons, falsework and bootstrapping techniques of contemporary suspension bridge construction require.

... THE STRETCHABLE IRON BELT

The original earth-to-GEO concept by Earle Smith suggested making the moving mass a stretchable belt of iron links, and suspend it from balloons entirely around the earth at the equator; then accelerating the belt, the velocity would expand the circumference due to centrifugal force, stretching it out to the desired GEO altitude. *(P.S. Although the Smith concept would have had its earth surface anchor in Texas, not on the equator as necessary for a single terminal structure to GEO.)*

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. ... FLYING THE NOSE OF A TINY REACTION PIPE: MICROELEVATOR

The reaction of a mass stream jetted backwards from a deflection nozzle of a pipe, is proposed by the author as a means of lifting the first small kinetic structure;

controlling the nozzle openings at the nose of the pipe guide the pipe along the desired path. A very small diameter tube, perhaps made of teflon tubing, would use electrostatics (instead of electromagnetics) to prevent abrasion of its internal surface; the tiny pipe would jet backwards by deflecting the mass stream from within the tubing. The first one would trace the entire path from ground to GEO and continue on around the planet to its earthsurface point of origin, where it would reconnect to form a continuous loop. Having carried a temporarily nonfunctional twin laterally connected all along its length, this second loop would be powered up to provide the opposite direction support of the downward half of each path.

... BOOTSTRAPPING FROM THE VERY SMALL TO THE VERY LARGE

Then a second tiny pair of channels would be carried around the planet on the first pair; then second pair gets powered up. A double sized one gets bootstrapped up next time; next one is 4 times that size. Electromagnetic versions follow that, until the large sizes get emplaced.

... LAUNCHING A BUCKETED LARGE REACTION PIPE

Like a waterwheel, a full-size bucketed structure might be launched by the deflection of a large grounded rocket motor. The velocity needs to be enough to carry it all the way to space and around back to the starting point, where it would be then electromagnetically accelerated enough to expand it to GEO altitude.

EARTH SURFACE-TO-SURFACE APPLICATIONS

Before these very large kinetic structures can be built

here on the Earth's surface, on the lunar surface, and on the martian surface, a lot of experience needs to be gained by utilizing them for smaller spans on the earth surface. Kinetic structural arches might support conveyor belts which span hundreds of miles, connecting coal deposits with local electric coal-fired powerplants. The kinetic arches could support water pipelines spanning from arctic glacial areas to deliver water to desert farming areas thousands of miles away, along great loops created by the Coriolis force. Oceans could be spanned, directly linking the continents, bridges now instead of just ships.

KINETIC STRUCTURES INTEGRATED INTO THE NEXT LARGER SYSTEM

The concept of the kinetic transportation structure system is laced into a larger picture of space colonization systems. One such system includes the following subset sequence outline, later in greater detail:
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** A determination by humanity to resume expansion of civilization
** From space shuttle technology, create modular wet-launch system
** Build small artificial gravity modular toroidal space habitats
** Research and build "siphon" type Lunar to Earth orbit transport
** Create kinetic-energy bridges of the surface-to-surface type
** Create the first surface-to-Clarke-Belt-orbit kinetic structures
** Build first 10,000 person "Island One" type space habitat
** Convert kinetic structural support energy source to solar thrusters

** Develop lunar material resource base, s/a using 2-body skyhook
** Convert lunar-to-Clarke Belt transportation link to massive link
** Create robotic construction system to build 1.5 million Island-1's
** 15 billion humans live in Clarke Belt & 1 billion on earthsurface
** Restoration of the Earth surface ecosystem to long term balance
** Earth surface as a cherished balanced genetic biodiversity resource
** Expanding outward, bringing life to other solar system resources

IN MORE DETAIL

... MOTIVATION

Motivation is a currently-missing essential for manifestation of the subject systems. Somehow the creative energy for such massive projects is missing from contemporary America, which rests on former Apollo glories, and steels itself against the grief of another Challenger- type failure, preferring to find hypnotic solace in the boob tube instead of bravely going onward to real achievements. The spark of interest in real improvement of mankind's options does still live however. Somehow the attention of the American "sleeping giant" needs to be aroused and focused toward ventures that can improve the well-being of civilization.

EARLY TESTING SYSTEM FOR EARTHNORMAL SPACE HABITATS: CENTRISTATION

While kinetic structure development is just getting started, smaller artificial gravity space habitats would

be put into low earth orbit, using modified reaction engine technology, to verify the basic concepts of such simulated earth environment habitation. We think that a spinning toroidal wheel about a mile or two in diameter could provide earth-normal gravity and atmospheric pressure, to provide ease of life for the majority of earth life forms, but it has not been tested, and it is an essential concept. Inside these first true space habitats, (perhaps to be called "Biosphere 3+") much of the extremely complex interlinked living and mechanical systems can be explored in reality.

To relatively quickly test concepts of artificial-gravity spinning space habitat systems, the technologies used to build Spacelab and the Space Shuttle can be used to create them. The modular sections of the spinning wheel-like habitat would be wet-launched (filled with the fuel to power the engines that lift them) by an unmanned winged engine vehicle analogous to a "tug". This vehicle could use Space Shuttle Main Engines on enough airframe to get the engines back to the launch site after boosting each wet-launch module into the desired orbital site.

The sections of the wheel-like space habitat are built as a complete station on the ground, connected together and pre-fitted with everything that can be done while later being filled with LOX and LH2 fuel for wet-launching. However, much of the checkout of the space habitat's functions can be done right on the ground this way, prior to its disassembly, launch, and reassembly on site in low earth orbit. Two identical such wheel stations could be built on the ground, the second for use in a mimicking of the activities on the real orbited station, and for use as spares for modules that might not make it all the way to the orbital site.

An essential factor here is that each of the sausage-link-like modules are built for dual use, both as a specifically designed pre-fitted section of a spinning artificial-gravity space habitat of a mile or so in diameter, and also as a one-time fuel tank to hold the fuel that is used by the SSMEs to launch the module into orbit. (Precedents are the wet-launched Spacelab of the '70s from Apollo hardware, and the concepts others have proposed for using the current Space Shuttle's disposable external tank as raw material for building a space station.) In this concept, free-fall high vacuum in-orbit manned assembly processes can be nearly eliminated. Given teleoperated docking, the entire ring of modules could be put into orbit, locked together into a ring configuration, degassed, filled with breathable atmosphere, and spun up to nominal artificial gravity even before the first human enters the space habitat. Once such spin-up and pressurization is accomplished remotely, all that remains for the human presence would be to remove and discard the collapsed internal liners, stock it with fragile supplies, and bring the humans and other life forms on board to live in it.

HIGH EFFICIENCY TRANSPORTATION SYSTEM CONCEPTS FROM MOON TO GEO

Although the entirety of the initial 1.5 million Island-One space habitats could be built of materials brought up on the kinetic structure bridges, the environmental stress on the earth ecosystem can be minimized by obtaining most of the structural materials from the Lunar surface, where there is abundant aluminum and glass, among many other raw materials. So a real "spaceport" could be built in GEO after the first several Island-One habitats are proven out there, and design becomes stabilized in practical use on site. It would be much easier to maintain a transportation link between GEO

and the lunar surface than it is from the earth surface. So a large transportation link to move construction materials from the Moon's surface to Clarke Belt construction sites would be very helpful.

Several potential high efficiency large volume transportation concepts exist for the unidirectional transportation from the Moon toward the Earth. Investigate forms of materials-pumps utilizing the greater depth of potential energy of the adjacent earth's gravity well, to lift materials up from its surface, past L-1 and down to the Clarke Belt orbit around the Earth.

.... THE MOONCABLE

One of the earliest (1971) concepts was the author's "Mooncable: Gravitational-Electric Siphon in Space", a tether from the lunar surface through L1 held in place by the weight of the tether on the earthside of L1, made of fiberglass in a constant-stress crossection configuration, used as a electric space elevator structure where electric tracks on the cable transferred the electrical power generated by the downward dynamic electromagnetic braking of the earthside payload was conducted over across L1 to raise more payload up the tethered cable to the L1 balance point, thus supplying the energy for its own transportation process, once primed, analogous to a siphon.

.... THE MASS DRIVER

The most famous transportation system proposed is by Dr. Gerard K. O'Neill, called the "mass driver". Analogous to particle accelerators and linear motors, buckets of lunar raw materials would be electromagnetically accelerated down an immense linear motor structure, launching it in the vacuum low gravity Lunar environment. This was envisioned

originally for use in building Island-One space habitats at the L4 and L5 Lagrange sites, 240,000 miles above the earth.

.... A MODIFIED SKYHOOK

In the late "70s, Dr. Hans Moravec proposed the "Skyhook", which would have been an immense cartwheeling cable whose center of gravity would be in high earth orbit, a cable so long that as it cartwheeled each end would in turn dip down into earth's atmosphere where appropriately timed and positioned payload could be "hooked", while equal incoming payload mass was hooked to the upper part of the cable; continuing to cartwheel, the earth-to-orbit payload would be raised, while the space-to-earth payload mass was lowered, conserving energy.

Perhaps some of the principles of this "Skyhook" concept could be put to use in a moon-to-earth orbit materials pump which continually circulates between a pickup point on the farside of the moon, to a dropoff point in earth orbit. The gravitational energy at the dropoff point would be slightly lower than the gravitational pickup level on the lunar surface, and the energy would be stored as angular momentum spin energy of the pickup vehicle's mass tethered to the picked-up payload mass. The bulk of the physical structure to be built in the Clarke Belt around the Earth would need to be built out of space resources, such as aluminum and glass from the Moon's surface. Altering the length of the tether during transit toward the earth, and precise timing of the release of the payload within earth's deeper gravitational well, would restore the energy used to make the pickup, and thus be used for the next pickup on the lunar farside. This would again be a "materials pump", or "siphon", as it's transportation energy would be maintained by the fortuitous closeness

of the much deeper gravitational well of the planet Earth... Like a siphon works.

.... ANOTHER KINETIC TRANSPORTATION STRUCTURE, BUT ON THE MOON

Eventually, however, probably another kinetic elliptical bridge structure would be built on the Moon, to boost raw materials to a stationary point perhaps as high as L1. Between L1 and GEO, conventional reaction engine transportation systems still seems necessary to fill in the remaining change in velocity.

POWER SOURCES FOR KINETIC STRUCTURE TRANSPORTATION SYSTEMS

One of the best features of the kinetic structure transportation system concept is that it uses electricity as its power source. Initially that electrical power would come from earth resources such as fossil fuel powerplants, nuclear and hydroelectric powerplants. The efficiency of not having to carry the fuel to lift the other fuel is apparent. However, an even more environment-conservation factor is seen when one considers the possibility of using solar-electric power stations in space to power the transportation system, and even supply a surplus of electrical power which can be extracted at the earthsurface contact point for use in earth surface electrical power grids, substituting for fossil fuels, nuclear and hydroelectric energy sources, preserving the ecosystem and maintaining a high level of electrical power for use by earthsurface civilizations, available on into the distant future. This electrical power would come from solar-electric "thrusters", which resemble a reaction engine hovering at constant altitude alongside the kinetic bridge structure. Solar energy would be converted into electrical energy using technology developed for Solar Satellite Power

Stations; however, instead of being converted into a microwave power beam, the electrical energy would be used to electromagnetically accelerate the downward-flowing side of the kinetic bridge's mass stream; the equal upward reaction would support the weight of the "thruster" under the earth's gravitational pull, being at an orbital velocity somewhat too low to otherwise maintain its fixed orbital altitude. Thus the overall kinetic structure transportation system would provide all its energy requirements, and could also provide extra for earthsurface electrical power grids as well.

THE EARTH-GIRDLING RING OF SPACE HABITATS: CLARKE BELT CITY

At least one ring of space habitats could be built in the Clarke Belt connected continuously to earth surface by the kinetic transportation bridge structures around the equator. There are very many possible configurations of space habitats useable here, not just the wheel-like torus configuration extensively described in NASA-SP413. I chose it as an example because that form of space habitat has been very extensively designed for use at L5, sometimes called the O'Neill colonies for Dr. Gerard O'Neill who was instrumental in their conceptualization. Each of these space habitats would have provided an inner diameter of 390 feet, have rotating artificial gravity with a wheel diameter of 1 mile, adequate atmospheric pressure, and passive radiation shielding. They had nearly self-sufficient agricultural areas of 180 sq ft/person, 36 sq ft/person for mechanical and life support functions, and comfortable, landscaped living space of 390 sq ft/person for 10,000 people each habitat. Given an a small separation apart, there is room for one and a half million of them along the circumference of the Clarke Belt. Multiplying 10,000 people each times 1.5 million habitats, shows that it could hold up to 15 billion people, much more than the

entire earth's population now (5.5 billion). So this design for a space habitat was chosen as an appropriate example.

However, this design for a habitat is not an optimum design for this application. At L5, it did not compete for sunlight with neighbor habitats, nor did it have to precess completely around once every 24 hours, as it would if rigidly linked to other habitats as an earth-circling banded torus in GEO. Other basic configurations might include spinning spheres within fixed shielding spheres, or lower-density torus's connected at their axis' only.

A second generation of an earth-girdling Clarke Belt space colony might be like a continuous 6-foot thick glass tube extending all the way around the planet in GEO, with another inner tube rotating inside the glass's mass shield, turning inner radius to outer radius fast enough to provide earth normal apparent gravity effects. This makes an essentially continuous space habitat, although it could be sectioned off at various places along its circumference.

IT MUST FEEL LIKE EARTH NORMAL

The more the internal environment resembles earth normal, the more able it will be to sustain a balanced ecosystem based on imported current earth life form diversity. Continuous circulation of people and other life forms, like pets, between earthsurface and the Clarke Belt abode would maintain compatibility and minimize accelerated evolutionary effects common to isolated ecosystems.

IT CAN MAKE EARTH NORMAL

With the potential of an excellent standard of living for all in the Clarke Belt City, at a level unattainable on most of the earth's surface, much of the human population could move there, relieving Mother Earth's ecosystem from the continued support of an oversize, largely sub-optimally competent civilization. The rest of the solar system offers its substance for use by mankind to build these artificial earthnormal dwellings, finally bringing the candle of life to them. And maintained by an average earthsurface tourist population of perhaps only 100 million, the entire earth surface ecosystem could become a cherished, pampered national park, a treasurehouse of genetic diversity.

AND SUMMARISING

There is an opportunity to apply General Systems theories to a potentially very significant transportation technology during its early development. The systems involved potentially cover nearly every aspect of life, as it would lead to massive space colonization. The basic kinetic energy supported bridge structure is envisioned something like an ellipse, with the internal mass stream accelerator at the low Earth surface contact point, and the high end of the ellipse contacting the geosynchronous orbit above the other side of the planet. Using the first bridge structure, the first 10,000-person "Island One" type space habitat could be built entirely from Earth surface resources, first of 1,500,000 to ring the planet....

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Earle Smith, for the concept of an elliptical kinetic structure from earth surface around to the geostationary orbit. *(P.S. Although the iron stretchable belt Smith concept would have had its earth surface anchor in Texas, not on the equator as necessary for a single terminal structure to GEO.)*

The National Aeronautics and Space Administration, for being instrumental in making things happen.

ABOUT THE AUTHOR:

James Edward David Cline tends to be an insightful, enthusiastic innovator, an INFP psychological type. A generalist from the beginning, with far too many interests. Working at White Sands Missile Range in radio telemetry while a co-op student, majored in physics, then psychology, in college; then, unknowingly being "co-dependent", dropped out of college to go find a wife. He worked or the FAA maintaining ground transmitter stations; did electro-optical work under ARPA contracts working for EHPA in Santa Monica; worked for Teledyne; was divorced; did development work on a spacecraft camera system at JPL under contract; worked on disk drive engineering at Pertec Computer Corp (co-authored a patent on MFM phase locked loops there); worked for Shugart Corporation (becoming an unusual non-degreed second level Electronics Design Development Electronics Engineer); and currently ekes out a living as an electronic technician for a car alarm company, VSE. Often is frustrated by politico-corporate power struggles which sometimes subtly interfere with his life when they consider his ideas too radical and threatening to their established plans. He does his "real work" writing on space & ground transportation concepts, much of it in the GEnie computer network Spaceport library (Genie M460, Space and Science Libraries, author J.E.D.Cline1); and also in the holistic health field ... still driven by that "generalist" energy.

941107 JEDCline

Starting in 1995, the author began attempting to tell about the KESTS to GEO concept using html on the free web page area on his earthlink.net account, http://www.earthlink.net/~jedcline and in 1996 had written on those pages:

A NEW TYPE TRANSPORTATION SYSTEM OPENS UP POSSIBILITY OF A GREATER WORLD

This website focuses on the possibility that a new and untested form of earthsurface-to-orbital-altitude transportation system (which perhaps could be called the Kinetic-Energy Supported Transportation Structure, or "KESTS") could provide a passenger/cargo capacity many orders of magnitude greater than presently available, and utilizing environmentally-clean electrical energy as its power source. (Perhaps this seems very implausible to the reader, resembling futuristic science fiction, but I invite you to continue reading.)

A "BIGGER" EARTH

Exploring this possibility further, such a transportation system could link earthsurface points along the equator to the orbital altitude where satellites move in relative stationary synchrony with the equatorial surface (known as the Clarke Belt, or GEO). The transportation system's massive cargo capacity would enable the construction of the beginnings of large-scale space habitats there in the Clarke Belt. Once basically perfected in tested design, a lunar infrastructure could provide the raw materials processing, fabrication of structure components, and delivery/assembly of similar habitats, all nearly completely robotically done. The entire Clarke Belt could be infilled with such space habitats, adding habitats at a peak rate of say, 100 habitats per day, each for 10,000 people. Thus the peak capacity required of the KESTS transportation system

would be 1,000,000 people per day, with their household goods and living essentials to support them, such as carbon, nitrogen, and hydrogen.

A GREAT PLACE TO LIVE

Given that these space habitats are designed and built to provide earthsurface-normal interior conditions, including rotation to provide 1-gee simulated gravity acceleration at the perimeter of the mile-diameter wheel-shaped habitats, and truly created to provide a significantly superior standard of living than is typical on the earthsurface, civilization could find itself essentially self-relocating to this extension of the earthsurface.

RESTORING THE EARTHSURFACE TO A HEALTHY BIODIVERSE BALANCE

Building this concept further, this would remove much of the human load from the earthsurface ecosystem, providing the opportunity to restore the earth's ecosystem to a long-term healthy balance again. Perhaps people would then choose to make the thusly rejuvenated surface ecosystem something like a "Earth National Park" for recreation vacation use. A human presence on the surface might reduce to a stable 1 million to 500 million people entrusted as caretakers to that biodiverse treasurehouse, along with aboriginal cultures remaining.

AND STRETCHING BEYOND EARTH

The human civilization, in the Clarke Belt, 22,300 miles above earth's equator, would be a starting point for expansion elsewhere in the solar system, such as the asteroid belt (with its raw materials for 1,000 earthsurfaces's equivalent of habitation area) and the moons of Mars and the outer planets. The already-

strong lunar materials infrastructure would provide resources for immense habitat-ships for this expansion phase.

ELECTRICAL POWER RETURNED TO THE EARTHSURFACE

Meanwhile, on the earthsurface, nearly all the electrical power would be derived from solar space resources and delivered to the surface such as by the KESTS system's electromagnetically-coupled mass stream accelerated by solar power thrusters hanging on it in space, or by the use of microwave beams to offshore rectennas.

THE KEY IS THE KESTS

Key to this scenario is the creation of that earthsurface-to-orbital-altitude electrically-powered immense transportation system, which could be called a Kinetic-Energy-Supported Transportation Structure, or KESTS. Let us begin with exploring its concept.

A starting point is to picture a globe, the planet of Earth, floating serenely in its orbit around our Sun. Look closer at the earth's equator, and then draw a circle around the earth's globe above the equator, a circle about 5 times the radius of the earth's sphere's radius ... this circle is the site of the new civilization named "GOHRC" here, the geosynchronous orbit 22,300 miles above the equator. Then add a KESTS by picturing an ellipse (an ellipse is like a circle that is grabbed and stretched in one direction), with the earth snuggled into contact with one end of the ellipse, and the other end of the ellipse at the GOHRC circle. This ellipse is the site of a KESTS (kinetic energy supported transportation structure).

Along this ellipse we will build the mental picture of the transportation system.

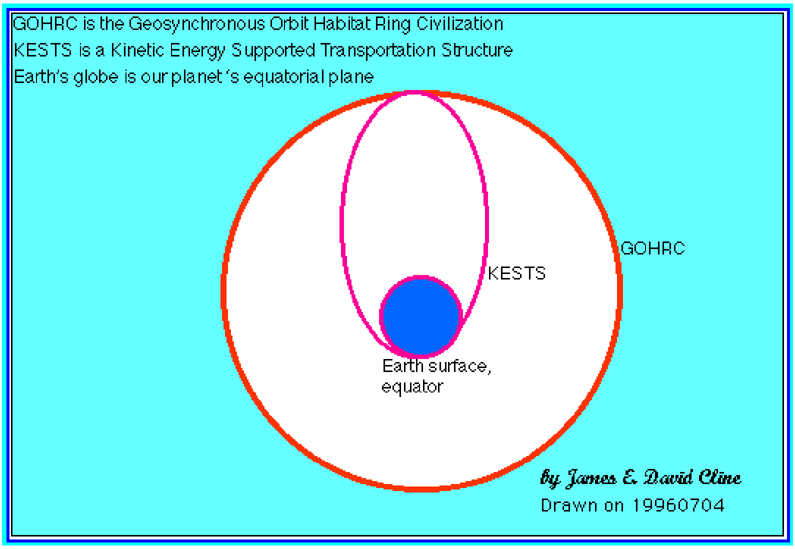
It is a highly elliptical orbit, with its high perigee point at GEO altitude of 22,300 miles, and low points a pair of earthsurface equatorial sites, one focus at the center of the earth. This is the actual orbit of an enormous mass stream circulating at above-orbital-velocities within the KESTS structure. However, this mass stream's elliptical orbit is compressed toward the earth by the distributed weight of vehicular railways and of evacuated tubing where within the atmosphere. Actually, it is consisting of contra-rotating pairs of laterally-connected mass streams, because only upward-moving mass streams can support external mass weight against the gravitational pull of the earth.

These mass streams, nicknamed here "EMCOM's", are streams of mass traveling at above orbital velocity, and are electromagnetically re-accelerated by electromagnetic accelerators located on the earthsurface and at SPS thruster sites hanging on the mass stream's downward portions. The mass streams lose velocity through supporting the weight of the rail system, and must have their energy continually replenished to continue the support.

The weight of the rail structure and of the "train-like" passenger and cargo vehicles acts to somewhat compress the elliptical orbital mass stream.

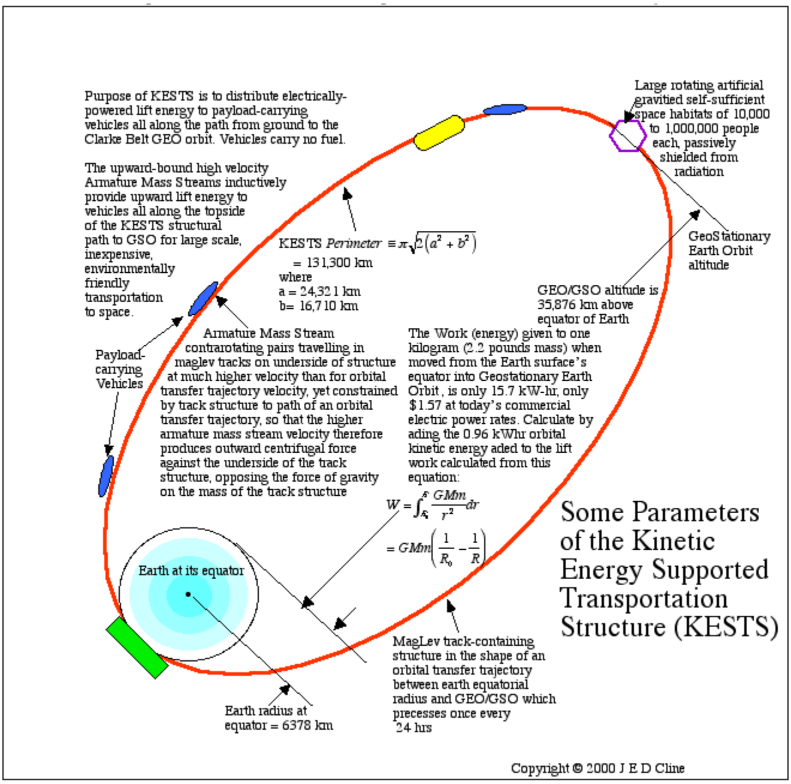
The vehicular rail traffic is also powered from the electromagnetically-coupled mass streams, trains, carrying people, supplies, structural materials back and forth between GEO-sited Gohrc and earthsurface.

Please now go to a greater depth in the Earth Plus: Extension of the Earthsurface conceptual design.



(This page most recently updated on 19960829. JEDC)

By 2000, the author had created somewhat more sophisticated computer graphics to help describe this, as he was preparing the first peer-reviewed published technical paper on the subject at an ASCE space conference. Here are some of the graphics, which describes some of the parameters involved in the overall structure, including the equations for calculating the energy added to payload along the elliptical structure. Some of these graphics were later also used on a dedicated domain on the web, http://www.kestsgeo.com



Titled "Some parameters of the kinetic energy supported transportation structure (KESTS)" the text within the diagram points out some significant aspects:

Purpose of KESTS is to distribute electrically-powered lift energy to payload-carrying vehicles all along the path from ground to the Clarke Belt GEO orbit.

Vehicles carry no fuel.

The upward-bound high velocity Armature Mass Streams inductively provide upward lift energy to vehicles all along the topside of the KESTS structural

path to GEO for large scale, inexpensive, environmentally friendly transportation to space.

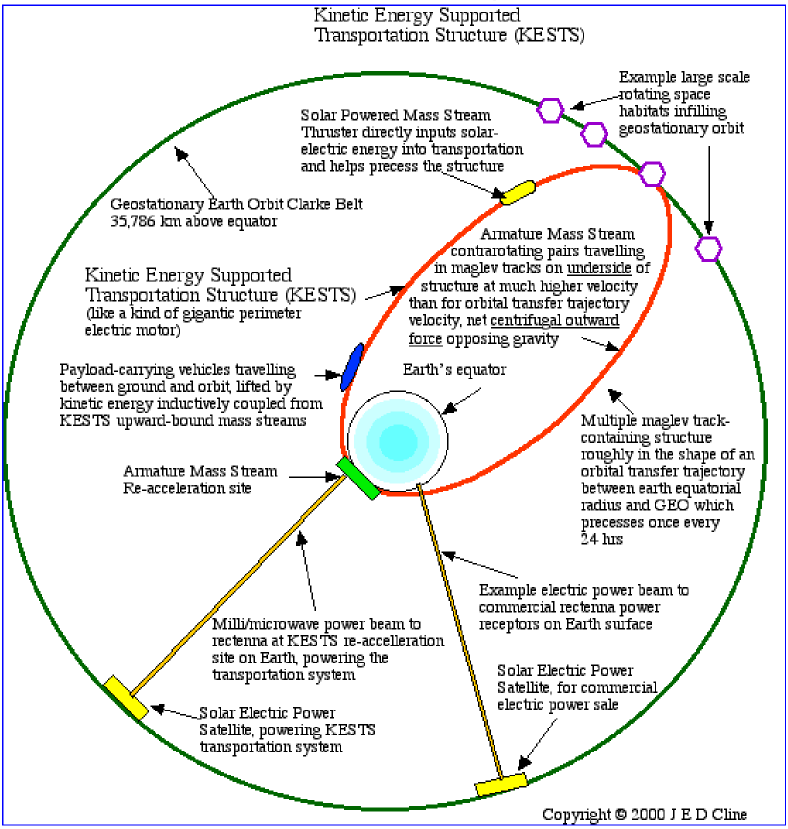
The work (energy) given to one kilogram (2.2 pounds mass) when moved from the Earth surface's equator into Geostationary Earth Orbit, is only 15.7 KWh, only $1.57 at today's commercial electric power rates. Calculate by adding the 0.96 KWh orbital kinetic energy added to the lift work calculated from this equation:
$W = GMm((1/R_0)-(1/R_1))$

It points out the maglev track-containing structure in the shape of an orbital transfer trajectory between earth equatorial radius and GEO which precesses once every 24 hours. The perimeter of the ellipse is 131,300 Km.

It shows the armature mass stream contra-rotating pairs traveling in maglev tracks on the underside of the structure at much higher velocity than for orbital transfer trajectory, yet constrained by track structure to path of an orbital transfer trajectory, so that he higher armature mass stream velocity therefore produces outward centrifugal force against the underside of the track structure, opposing the force of gravity on the mass of the track structure.

At GEO altitude, it shows the large rotating artificial gravitied self-sufficient space habitats of 10,000 to 1,000,000 people each, passively shielded from radiation.

This is another of those graphics drawn by the author on the computer in 2000, this one showing the overall system of the KESTS to GEO and the major envisioned facilities it would enable built and operated in GEO.



On the following page is the same system-wide graphic but with text added describing its key features:

Vehicles carry no fuel; they continuously inductively extract kinetic energy from the high velocity upward-bound armature mass steams circulating around within the stator transportation bridging structure spanning between ground and geostationary orbit.

A totally electrically powered transportation system ground to GEO and back.

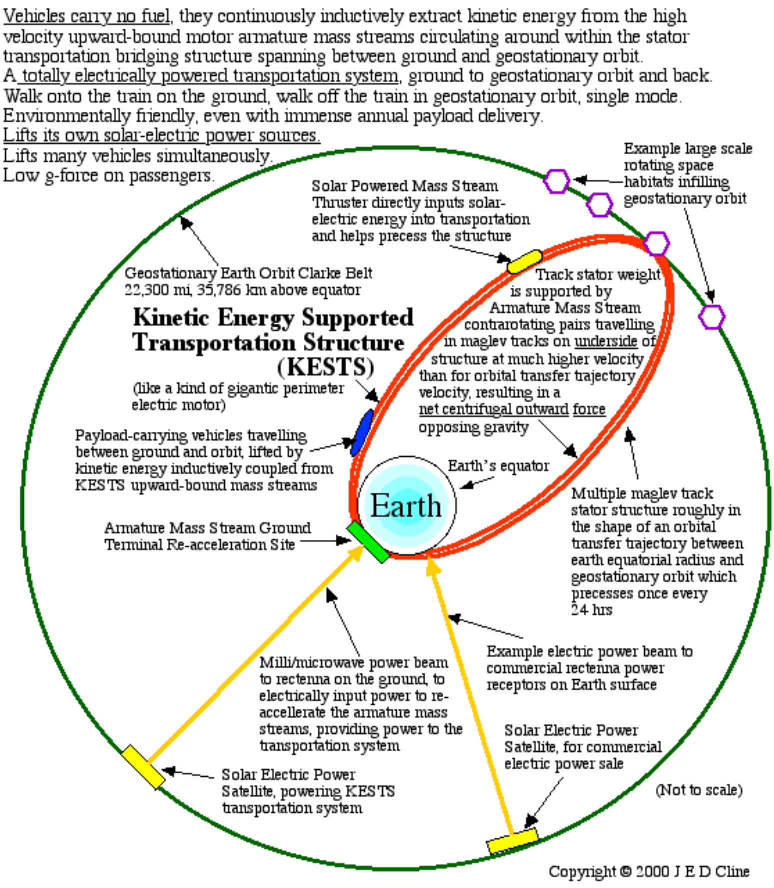
Walk onto the train on the ground, walk off the train in GEO, single mode.

Environmentally friendly even with immense annual payload delivery.

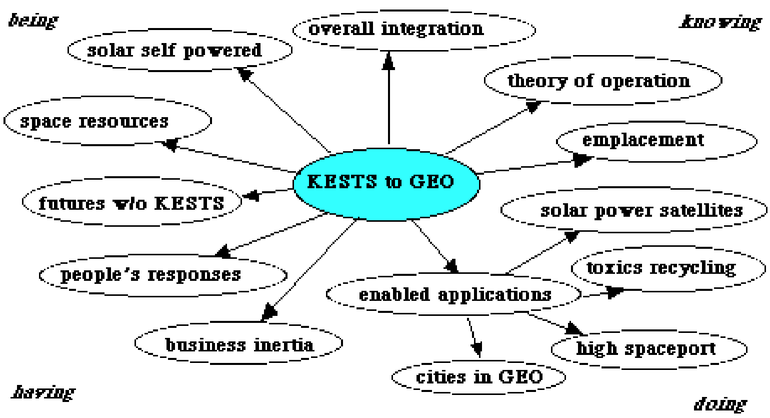
Lifts its own solar-electric power sources.

Lifts many vehicles simultaneously.

Low g-force on passengers.


Vehicles carry no fuel, they continuously inductively extract kinetic energy from the high velocity upward-bound motor armature mass streams circulating around within the stator transportation bridging structure spanning between ground and geostationary orbit.
A totally electrically powered transportation system, ground to geostationary orbit and back.
Walk onto the train on the ground, walk off the train in geostationary orbit, single mode.
Environmentally friendly, even with immense annual payload delivery.
Lifts its own solar-electric power sources.
Lifts many vehicles simultaneously.
Low g-force on passengers.
Example large scale rotating space habitats infilling geostationary orbit
Solar Powered Mass Stream Thruster directly inputs solar-electric energy into transportation and helps precess the structure
Geostationary Earth Orbit Clarke Belt 22,300 mi, 35,786 km above equator
Track stator weight is supported by Armature Mass Stream contrarotating pairs travelling in maglev tracks on underside of structure at much higher velocity than for orbital transfer trajectory velocity, resulting in a net centrifugal outward force opposing gravity
Kinetic Energy Supported Transportation Structure (KESTS)
(like a kind of gigantic perimeter electric motor)
Payload-carrying vehicles travelling between ground and orbit, lifted by kinetic energy inductively coupled from KESTS upward-bound mass streams
Earth's equator
Earth
Multiple maglev track stator structure roughly in the shape of an orbital transfer trajectory between earth equatorial radius and geostationary orbit which precesses once every 24 hrs
Armature Mass Stream Ground Terminal Re-acceleration Site
Example electric power beam to commercial rectenna power receptors on Earth surface
Milli/microwave power beam to rectenna on the ground, to electrically input power to re-accellerate the armature mass streams, providing power to the transportation system
Solar Electric Power Satellite, for commercial electric power sale
Solar Electric Power Satellite, powering KESTS transportation system
(Not to scale)
Copyright © 2000 J E D Cline

In 2004, another approach was tried on the earthlink.net/~jedcline web pages, another image mapped graphic linked to pages describing the specific parts in greater detail, like the preceding graphics; but this time instead of a diagram of the structure itself, a cluster diagram was used, with each ellipse linked to a corresponding page:



The kestsgeo.com web pages mostly utilized graphics from the earlier earthlink.net pages the author had made, plus new graphics related to the various technical papers the author was writing and presenting at various space conferences describing the subject.

In the meantime, besides the activity to use the internet web page media to communicate the concepts, an earlier attempt was made in 1997 to get a formally presented and published technical paper via a space conference was done, as described next.

Kinetic Energy Supported Electrically Powered Transportation Structures

This is the paper that the author presented at the Space Studies Institute's space conference at Princeton, NJ, in May 1997. However, although the author had thought that the esteemed space visionary group, founded by the late Dr. Gerry O'Neill, would eagerly embrace this new vision to achieve their goals of large scale space colonization, including producing Solar Power Satellites as an early product; unfortunately the author did not realize they had some other agenda, perhaps only their leader's specific vision in the academic atmosphere. After making the paper's presentation, the author was ridiculed and they refused to publish the paper. Two years later they refused to allow the author's re-written paper, but would allow a poster session of it; but that was not within the author's budget. So, it now finally gets published, in this book, eleven years late. Better late than never, it is said.

KINETIC ENERGY SUPPORTED ELECTRICALLY POWERED TRANSPORTATION STRUCTURES

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Abstract

Generalizing and expanding upon specific ground-to-space concepts created in the 1980's, Kinetic Energy

Supported Electrically Powered Transportation Structures (KESTS) have the potential of enabling truly massive space colonization in earth orbit. Compressive strength of materials limitations are bypassed by using the kinetic energy of a stream of orbital velocity mass elements circulating within the loop structure, compressing their trajectories toward the planetary center, supporting weight against the force of gravity. Electromagnetic coupling of the kinetic energy of the stream of mass elements also supports the weight of the evacuated tubing in which it flows, and transfers propulsion energy to vehicles traveling along its vast bridge-like structure. It can also serve as a power transmission and storage link between solar satellite thruster powerplants and the earth surface's electrical power grids. Stabilized by laterally-coupling mass stream pairs and by active position feedback servo systems, these are dynamic structures. The massive potential payload capacity of such electrically powered transportation structures linking earth's surface and earth orbital altitudes, conceivably could enable construction and habitation of an Orbital Habitat Ring around the Earth, a site where civilization can resume expansion utilizing the great resources of space. Perhaps these concepts can inspire humanity to reach new heights of healthy vigor.

A Brief Description of the Idea

Examples of kinetic energy being used to support structural shapes have been around a long time. Consider the kinetic energy of pressurized gas within a balloon or spacecraft fuel tank enabling the shape of that structure and its ability to carry load. Consider the arch of water in a fountain bringing water up to waiting

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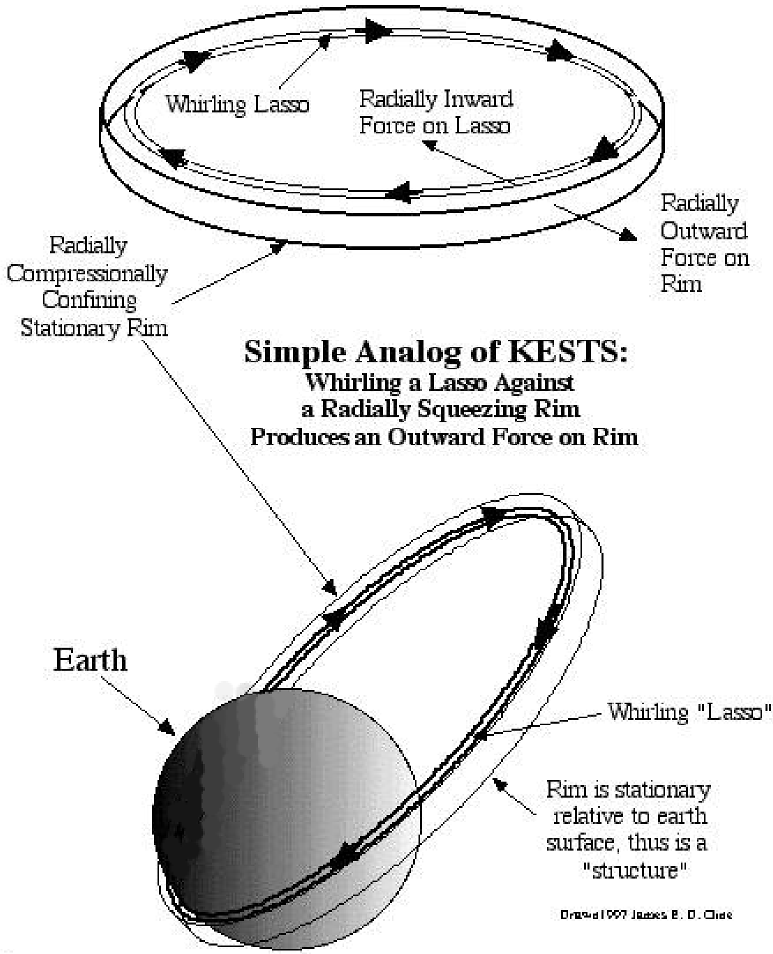
lips. And consider the cowboy's lasso's loop, maintained in a circular shape by the spin of the circle of rope.

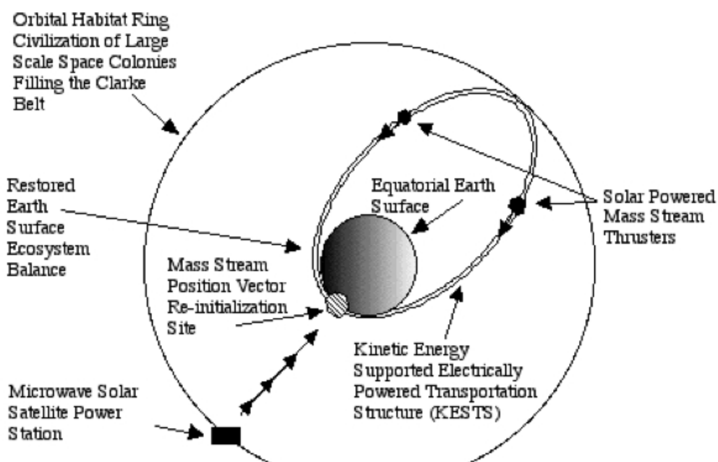
Let's expand on that lasso's loop picture. Imagine that the whirling lasso is almost frictionlessly sliding around inside a rim; the rim is slightly smaller than the lasso's



↵

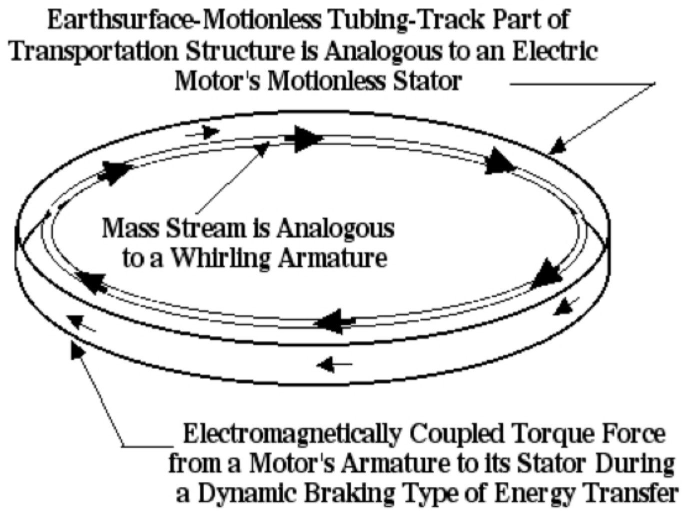
loop so as to squeeze the lasso into a smaller radius than it would naturally assume, thus the lasso's centrifugal force is producing a small outward radial force on the compressing rim.

Then imagine that the rope's loop is sufficiently large as to go completely around the planet, contacting the planetary surface where electric motors input the energy for maintaining the loop's rotation; and continuing on to arch high above the far side of the planet before returning to the ground contact point, in a circulating loop.



KESTS to an Orbital Habitat Ring
Infilling the Clarke Belt

To couple the electrical energy into the loop, make the loop the rotor of an electrical motor, perhaps looking more like a linear motor there.

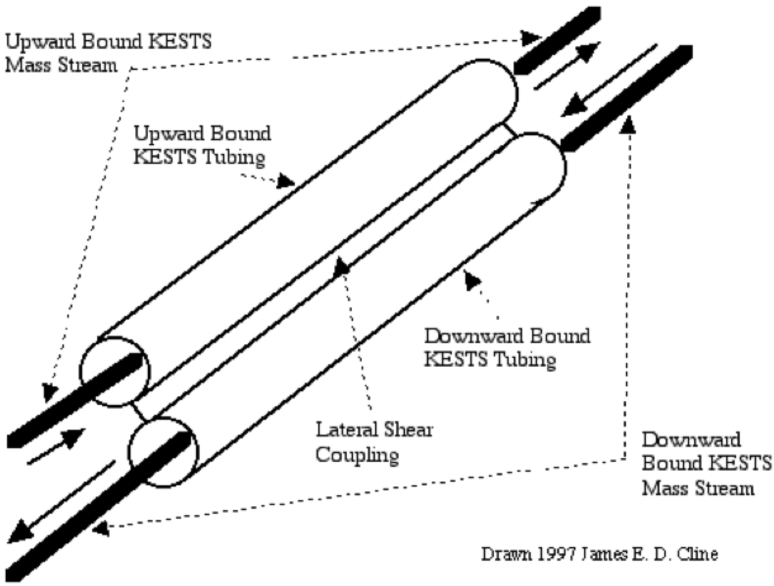


Electric Motor Analog of KESTS

Drawn 1997 James E. D. Cline

To prevent the rope/loop from burning up in the atmosphere, enclose it within evacuated tubing. Support the weight of that tubing by compressing the trajectory of the rotating loop toward the ground, electromagnetically coupling the distributed weight of the tubing to the spinning loop. That tubing is stationary relative to the earth surface, and appears as if it were a structure upon it. Call the rotating lasso's rope a “mass stream.” Since the earth is rotating once every 24 hours, the structure must also do so, being attached to the ground; so to link this planetary rotation to the structure, pair up counter rotating mass streams, bonded laterally together by their tubing to force a common trajectory between them. And electromagnetically couple the pulsing passage of the mass stream past any point on its circumference to

provide lift energy to vehicles clinging to tracks along the tubing. And thus we have a picture of a basic form of a KESTS, or Kinetic Energy Supported Electrically Powered Transportation Structure. Such a transportation structure potentially could reach as high as Geosynchronous Earth Orbit.



Section of a Laterally-Coupled Counter-Rotating Mass Stream Pair

KESTS: Kinetic Energy Supported Transportation Structures

A generalized concept unifying the visionary 1980's structural concepts of Hyde, Loftstrom, and Smith is offered here, and expanded upon.[1,2,3]

Since the 1980's, such megaprojects have been disregarded in favor of scout-type space exploration, but the current impending crisis of mankind's weight upon the earthsurface ecosystem, suggests re-consideration and expansion of these concepts for a massive migration of civilization into nearby space resources. New ideas for emplacing these enormous structures are described, and the applications enabled by new forms of such structures. A new way of self-powering the structure from solar electric mass thrusters is described here, which potentially could also supply surplus electrical energy to earth surface commercial power grids. It is offered that space technology thus has a chance of enabling a vast human civilization in near-earth space while also enabling the restoration of a balanced earth surface ecosystem, which surely would be very good news for a conscientious humanity's long term survival prospects.

A kinetically-supported active structure would be, in general, a structure which has as its primary resistance to deformation, the force of deflection of a large high velocity mass stream circulating within the structure; feedback control mechanisms intelligently actively guiding the application of this force based on the changing loads on the structure. The potential length of a kinetically-supported active structure is enormous, as is its expected payload capacity. Such rail-like transportation structures would far exceed the dimensions normally limited by the strength of materials, by being supported by the electromagnetically-coupled aggregate downward deflection of high velocity mass streams circulating within them. Their payload capacity potential thusly would be vastly greater than that which conventional reaction engine technology can provide, and doing it with minimal environmental impact. They would be active structures, as contrasted with passive structures,

in that they would use feedback-stabilized energy to maintain them. Similarly, kinetically supported active structures would use position sensing in a feedback path to the ground mass stream re-acceleration point(s) modifying the internal mass stream velocity vectors so as to counteract deflections of the structure due to shifting payload weights, oscillation, wind loads, and response to impacts that might happen. Once built and supported using ground-based electrical power, space-based solar electric power would provide energy for it, such as dedicated SSPS in GEO, and/or solar powered thrusters located high along the structure providing all of the support and transportation energy used by the structure, and provide some intermediate active position feedback corrective vectors modulating the mass stream at their locations. The basic configuration of a KESTS structure, of the type being mostly discussed here, would connect at the equator and loop around the earth extending to far above the far side of the equator. Generally, kinetically supported active structures would utilize electromagnetic exchange of energy between masses in relative motion between each other, resembling an enormous distributed linear motor. They would have internal storage of an immense supply of energy, composed of the kinetic energy of pairs of very large continuous mass streams circulating along its length moving at orbital velocities, also intrinsically distributing transportation energy to payloads moving along it. They consist of pairs of laterally-coupled tubes linking counter rotating mass streams so that the whole structure rotates with the earth's rotation.

The Overall Concept Into Which KESTS Fits

The overall concept is of a technology of efficient large-scale transportation of people and goods which involves extreme changes in altitude, potentially from

earthsurface as far up as geosynchronous earth orbit. The potential of such an adequate transportation system to enable much of the near-future human population to choose to move into rings of near-earth-surface-normal-interior space habitats could enable the restoration of the earth surface ecosystem back to long term normal balance, while also enabling humanity to expand civilization enormously by living in man-made habitats, as now but located close in earth orbit, essentially free from need of resource destruction on the surface ecosystem thereafter. This very worthy goal hopefully balances the highly conjectural state of the technology at this point in time.

Building transportation structures, a form of bridges, to connect the ground all the way up to orbital altitudes may seem absurd; however, such structures are being considered here. The compressive strength of known materials is very inadequate to the task of bearing the weight of such immense structures, so the compressive load would largely be carried by compression of the trajectory of mass streams circulating within the structure at above orbital velocities. The mass streams are referenced to the earth surface, so the load of the weight of the structure, and payload moving in vehicles upon it, is transferred by the mass streams to the ground load bearing. The pulsing electromagnetic energy of magnets contained within the mass stream is inductively coupled to the distributed load of the structure, and to the vehicles traveling upon the structure. Similarly, energy is put into the structure by electromagnetic coupling to the mass stream.

Basic Principles Of Kinetic Energy Supported Structures

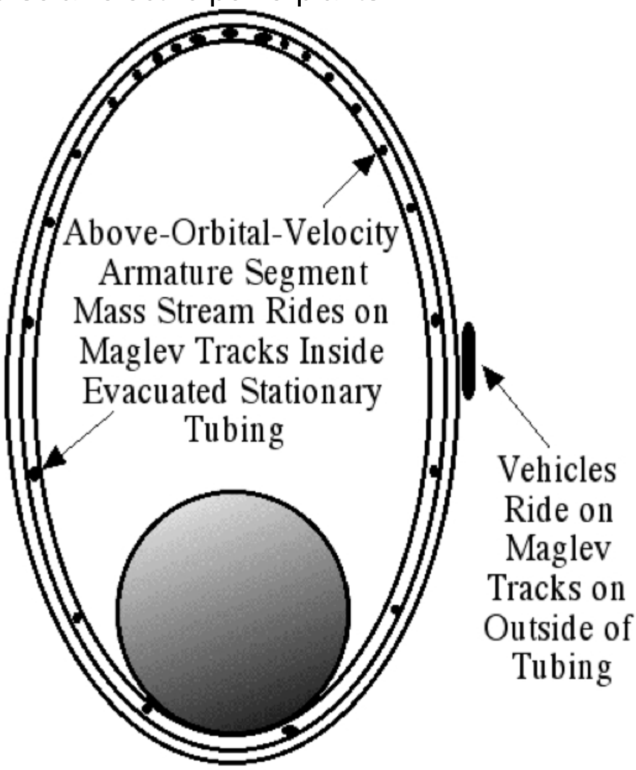
Instead of building with tensile and compressive members, which have limits in their strength of

materials and thus limits to their size, consider the possibility of using stored energy within the bridge structure to support it, to augment the chemical bond energy energy now providing its strength.

Picture, if you will, the immense kinetic energy of a massive pair of orbital velocity mass streams, flowing in a hard vacuum, circulating within channels along the length of such a bridge structure. The kinetic energy of those mass streams are electromechanically coupled to the structure of the bridge, providing support for the bridge structure and its live loads through downward radial compression of the mass stream trajectories, concurrently distributing energy to move those live loads along its length from the Earth's surface up to the desired orbital altitude and back down again to the Earth's surface, in a laterally coupled parallel pair of continuous loops. Most of the energy is stored within the kinetic energy of the circulating mass streams; only a small fraction of the mass stream's kinetic energy would be used each time around the loop, thereby providing a buffer against transients.

Generally, a KESTS would maintain its shape against forces acting against itself by using the kinetic energy of rapidly moving mass within itself to resist those forces. Energy coupling between the mass stream's packets and the tubing/track/vehicular parts of the structure is electromagnetic. The mass stream's intrinsic path is maintained by automatically re-optimizing the velocity of each of the packets at thrust points along it's path at the earthsurface contact re-initialization sites, thrusters, and benders. Significant features of such a transportation system are that it would use electrical energy instead of chemical energy for transportation of payloads, would use part of its internally stored kinetic energy to do the work both of holding the structure up and to power payload vehicle

movement along its path, would be stabilized against changing forces against them by active position feedback servo systems, and eventually provide excess electrical power to associated consumers as well as provide its own power from associated space-based solar-electric powerplants.



Relationship of KESTS Maglev Tracks, Tubing, Mass Stream, and Vehicles

Dwn 19970528 JEDCline

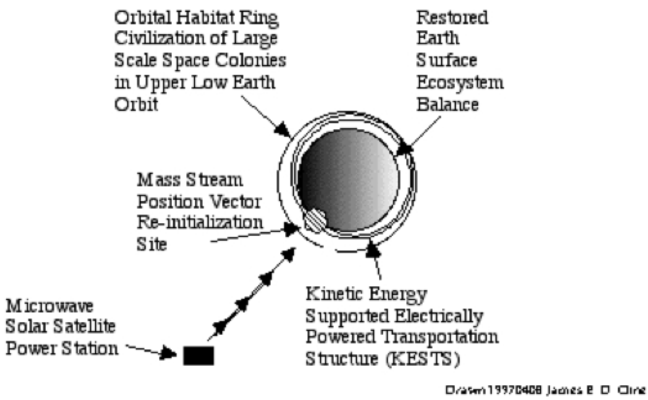
General Forms Of Kinetic Structures

KESTS are structures raised upon a planetary surface which resists the force of gravity by utilizing downward compression of a high velocity mass stream circulating around within the structure. There are several potential shapes of KESTS:

1. The shape of a vertical tower or fountain, where mass streams circulate vertically up and down, requiring a strong magnetic field short radius turn-around half loop on the ground to catch the downward moving mass stream, and swing it around back upward again while restoring its exit velocity;

2. Surface-to- surface arch, where the two surface contact points are widely separated, which also requires a short radius turn-around half loop on the ground at each end of the bridging arch; and

3. surface-to-space above the far side of the planet above the equator there, which utilizes the planet's gravitational field itself to turn the mass streams around. This latter shape, which is the form primarily being considered here, has several variations, including those with two surface contact sites which are mirrored about the equatorial plane, and multiple KESTS which are interlocked at their crossover points in space to form a web. A KESTS which circles the planet, from the surface out and around the planet to high above the far side of the globe, such as to LEO or GEO, and continuing on around to its surface starting site, could be considered a special case of the arch shape, where the two surface ends of the arch bend around the round planet to meet at the same site, and the round planetary gravitational field provides the primary force to bend the mass streams around into a continuous circulation loop.

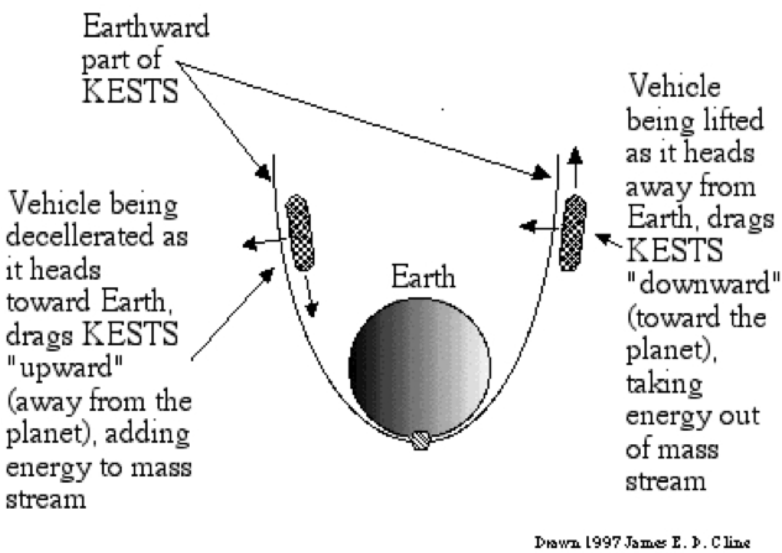


KESTS to an Orbital Habitat Ring in Low Earth Orbit

KESTS Dynamics

The dynamics which can be envisioned at this time for this form of KESTS involve the coupling of the mass stream to its environment. In some ways resembling the spinning rotor of an electric motor, the mass of this rotor is going around faster than the orbital velocity at any point, held lower by the weight of the sustained loads of passive structure and its live loads. The rotor, or mass stream, couples to its environment only through electromagnetic and electrostatic fields. Pushing from the earthsurface contact anchor re-initialization site, the mass stream is re-accelerated and repositioned to restore energy consumed along the KESTS pathway, compensating for live loads and lateral forces on the KESTS. From this re-initialization site, the mass stream heads back upward,

electromagnetically dragging weakly against the passive structure around its path, as well as dragging against coupling to vehicles tapping that energy to lift them up the KESTS. This passive structure involves the evacuated tubing in which it flows, the shear coupling between counter rotating stream tubes, and the guidance tracks for live loads such as passenger vehicles. Live loads being lifted along the KESTS exert a downward force on the structure's mass stream, but live loads which are decelerating back toward the earth surface exert an upward force on the tracks thus adding energy back into the transportation system.



KESTS Vehicular and Mass Stream
Energy Conservation

Other major forces on the mass stream come from passive weight "benders" for changing the shape of the KESTS, and solar-electric thrusters which support their

sub-orbital velocity's weight by reaction to thrusting downward on the downward-flowing mass streams, thus adding solar-derived energy to the mass stream's energy.

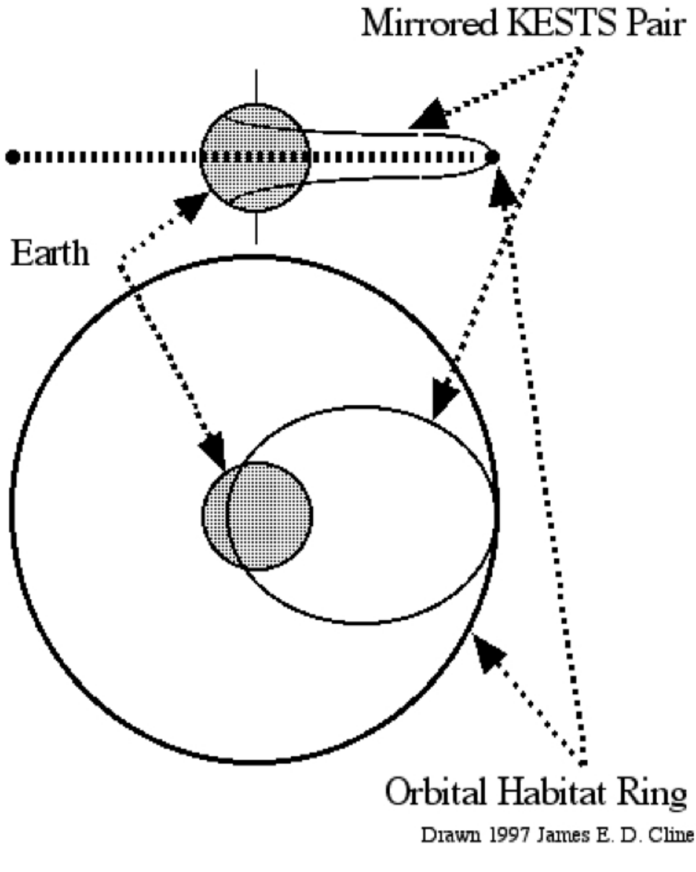
The Mass Stream Packets

The mass stream is composed of packets performing several functions. Their primary function is to provide the storage and exchange of the kinetic energy which supports the compression load of the structure's weight, and distributes energy to move payload along the structures. Some packets may also function as vehicles transporting payload within the mass stream itself, and other forms of packets may be the payload itself on a one-way trip up or down as raw material. Packets need to be designed to resist contact with each other and with the tubing wall, somehow avoiding such contact wear; so perhaps they will need periodic automatic inspection and repair/replacement. Packets exchange energy within the KESTS by rising/falling in a gravitational field, and electrically through permanent and induced magnetism, and electrostatically. The electric field energy exchanges support the structure, center the mass stream within the tubing, input and extract energy to the mass stream, sense packet position and velocity, for re-initialization processes, and prevent physical abrasive contact.

Planetary Body Access Structural Shapes

Besides the vertical loop and the parabolic arch shapes, there is another basic form. If the mass stream is sufficiently large as to extend upward at a tangent to the earth's surface, it could continue on to be gradually bent by the earth's gravitational field to circle the earth to return to its point of origin, such as from a point on the equator circling around the earth back to itself. All

the way around the Earth, extending far out into space on the opposite side of the planet from its surface contact central point. Non-equatorial surface contact points are conceivable, needing a mirroring contact point on the opposite side of the equator from itself, where either direct turn-around loops are located, or instead full loops interchange at their upper crossover point.



Equatorialy-Mirrored KESTS

Applications of Planetary Body Access Kinetic Structures

Such large kinetic structures could provide transportation capability millions of times greater than what we currently have. This massive capacity would totally change mankind's relationship with space. The experience of building and utilizing a Stanford Torus space settlement in the Clarke Belt, constructed entirely of resources from the earth surface, could teach us a lot which would help in the design of more of the settlements, as well as learn technological and sociological techniques useful on Earth herself. The first space settlements in the Clarke Belt, permanently connected to earth surface by the kinetic structures, create a beachhead for returning the Moon, this time to create the industrial resource base for building the main structure of vast numbers of those settlements in the Clarke Belt. For example, building just one continuous string of Island-One type 10,000 resident-each Stanford torus space settlements all the way around the earth-circling Clarke Belt, would provide residential areas and supporting agricultural areas for up to 15 billion people. This would enable a vastly expanding human civilization while taking their load off of Mother Earth.

Emplacement Of KESTS

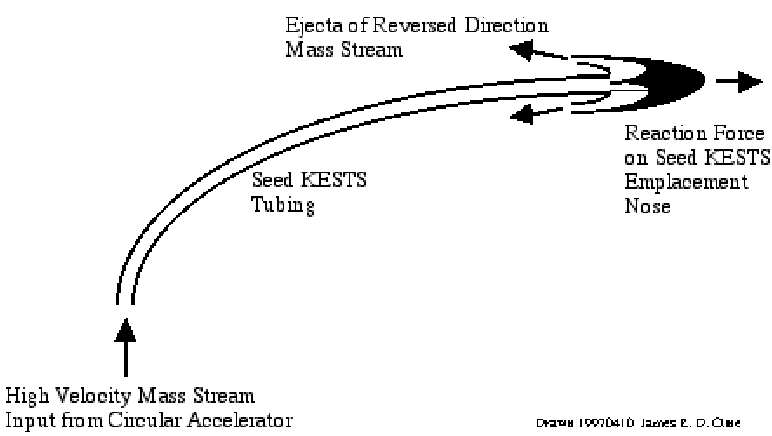
The enormous difficulties in emplacement of KESTS into space from earth surface is sometimes glossed over, in the enthusiasm for the tremendous potential of the KESTS to provide truly massive efficient payload transfer between Earth surface and space near the Earth. However, there is frustration in trying to figure out how to get the KESTS up there in the first place. Suggestions so far have been by Keith Loftstrom, Rod Hyde, Earle Smith, and the author.

Early Emplacement Concepts

The techniques by Loftstrom and Smith involve laying the loop mechanism on Earth surface across at least one ocean, then accelerating the loop mechanism until it rises, or by carrying the upper portion of the loop aloft with balloons prior to acceleration. Hyde's vertical form of KESTS would be built by inserting new evacuated sections at the Earth surface launch point, incrementally raising the upper reflector end as sections are added at its surface base.

KESTS Emplacement by Flying Nose-Reaction Propulsion

The thrust of a mass stream against a structure which produces a sudden 180 degree turn around of the mass steam, much as Rod Hyde's “Starbridge” fountain structure would have done, suggests another emplacement means. Making the tube diameter a small fraction of an inch and of flexible tubing would enable a



KESTS Emplacement Using Nose Thruster Mass Stream Reverser Technology

small ground construction site and expendable R&D launches. A large circular mass driver would accelerate the mass stream up to, say, 20,000 mph while flowing within evacuated tubing which is configured as a large coil. At the start of the launch the weight of the nose thruster, which provides the 180 degree turnaround of the mass stream within itself, needs to be much less than the force of the mass stream slamming against it to be electromagnetically thrown backward by the nose thruster. Headed upward, the nose thruster would resemble a conventional reaction engine launch, if the version merely releases the mass stream into the environment once it has expended its push against the nose thruster; more advanced versions would provide laterally-coupled return tubing for the reversed returning mass stream packets. The weight of the rising mass of the uncoiling tubing would be supported by distributed electromagnetic against the mass stream hurtling through it, as in the conventional KESTS form. The nose thruster's trajectory would arch over and down to the site of the other end of the KESTS arch. Experience with building ever-longer arches would increase until the arch has completely circled the planet to have its landing site be at its launch site, thus emplacing a seed KESTS into space, for bootstrapping construction of full capacity structures. Nose thruster KESTS emplacement technology offers seed-bootstrapping KESTS, temporary KESTS, and special one-way materials delivery systems..A half-arch from ground to GEO conceivably could provide one-way delivery of construction materials; for example, if the mass stream is a glass fiber with magnetic inclusions in it, delivered at, say, 4 miles worth per second, accumulates respectably.

Chemical Reaction Engine Technology Emplacement

Another, rather brute force emplacement method would use chemical reaction engine technology to initially accelerate an upward bucket chain of objects that form the energy storage mechanism that will eventually support the KESTS. This technique establishes a tubeless KESTS mass stream first, then installs evacuated tubing around it, forming the basic structure of the KESTS. The tubeless KESTS is an immense chain of magnetically-coupled objects or packets, accelerated first by a modified form of chemical reaction engine technology or by electromagnetic rail technology. The front packet takes the brunt of the punishment, slamming through the air at meteoric velocities. The following links in the chain are packets which are in the wake of the lead packet, and have less effort to eject the air molecules that get in between the packet chain links.

The chain of orbital velocity missiles starts at earth surface, rapidly goes upward out beyond the atmosphere, coasting in trajectory around the planet to re-entry headed for its point of origin. As the chain of packets rise, some of their kinetic energy is converted to potential energy, and the average spacing between the chain links must decrease; so the chain is built to fold like an accordion in the hard vacuum to expand the width of the mass stream at higher altitudes. When the lead packet reaches the starting point, it is joined to the chain at that point, and re accelerated.

The contra-rotating version is then started up in the opposite direction alongside the new tubeless KESTS. It too loops around the Earth to rejoin itself at the surface contact re acceleration site. The two chains of orbital velocity packets are configured to

electromagnetically couple laterally, using electromagnetic position lateral linking nearly frictionlessly.

The laterally-coupled pair of sheathing tubes are then laid upon the two speeding chains of packets, its weight supported by the rising side of the dual chain of packets, sliding on the electromagnetic bearing surfaces of the outside surface of the chain of packets. Laid along the length of the KESTS, it is next sealed and evacuated. By this time all re-acceleration of the KESTS packets is electromagnetic.[13]

Emplacement as a Millimeter Microwave-Boosted Launched Mass Stream

Similar to launch by the blast of chemically powered reaction engine exhaust against it, multiple beamed millimeter wave energy sources perhaps could utilize hot air plasma acceleration technology to emplace seed KESTS.[14]

Payoff or Value

What is the value of enabling a resumed vigorous expansion of human civilization while also enabling the restoration of the earth surface ecosystem? The intent of this paper is to inspire hope for such a near-future major space-based civilization, enabled by an earth surface to space transportation system adequate to the task of transporting every existing human being into space, if need be, to an Orbital Habitat Ring encircling our planet.

An indefinitely long improvement in the standard of living for humanity in general, would be made possible by a transportation system adequate to the task of establishing a massive beachhead in earth orbit,

increasing access to space resources, increasing how far we can go and how much we can carry there. With enormous increases in room to grow, raw materials and abundant 24 hour per day solar energy, resource wealth can increase life satisfaction for all. This all could uniquely be made possible by a mature Kinetic Energy Supported Electrically Powered Transportation Structure technology. More specifically:

1. Discoveries made during pure research on KESTS technology.

2. Over water bridge spans far exceeding that possible using contemporary structural materials.

3. Heavy lift high capacity electric powered access to earth orbital altitudes for large spacecraft assembly for deep space exploration and commercialization.

4. Provides access to create a very large scale space colonization ring of earthsurface-normal interior habitats, enabling shift of human population center to that location, becoming primarily based on space resources thereafter.

5. Enables the restoration of the earthsurface to the ecological balance state resembling pre-civilization qualities, for preserving and expanding biological diversity resources; enables most of the earthsurface to become an "International Park Campground" for vacationing people from the Orbiting Habitat Ring.

6. Perhaps most importantly, it offers a way to unite mankind into a huge cooperative venture toward a common goal's tasks.

Performance Characteristics

1. On KESTS, vehicles traveling between earth surface and earth orbital altitudes do not carry propulsion fuel. This contrasts with conventional launch vehicles, which must utilize the great majority of their lift capacity to lift the fuel necessary for orbital insertion. Conventional vehicle return to earthsurface requires energy-wasteful heat-shielded dissipation of vehicular energy during the atmospheric reentry; when deceleration of vehicular mass during return to earthsurface along KESTS, occurs, the force supplies lift energy to the KESTS and thus returning energy back into the transportation system.

2. KESTS distribute vehicular propulsion electrical power all along their structures, without resistive losses of electrical wiring, and without sliding electrical contacts to extract power for propulsion, since propulsion energy is coupled inductively from the mass stream's pulsing magnetic fields.

3. KESTS would somewhat resemble an electric railway-carrying bridge structure.

4. Powered by electrical energy. Sources of this electrical power could include existing electrical commercial power grids, "conventional" SSPS in GEO, and Mass Stream Solar-Electric Thrusters on the KESTS. The latter two sources may additionally be able to supply electrical power back into the earth surface electrical commercial power grid.

5. KESTS would be "active" structures, analogous to a kind of airplane that is piloted high in the sky while propelling itself by pushing on the ground below it. Stability is highly dependent on servo position feedback mechanisms which strive to predict load transients and

compensate for them in advance by appropriate changes in the exit velocity vectors of the counter rotating mass streams at the earth surface re-initialization site; these advance compensations would ripple through the KESTS at mass stream velocity.

Enabling Technologies or Systems

1. Hard vacuum technology, and hard vacuum materials technology.
2. Mass driver technology, as a starting point for design of the earthsurface mass stream's velocity re-initializer, and for the energetic interactive coupling between the mass stream and the tubing/track/vehicle complex which it supports.
3. System analysis, which needs to be expanded to provide integrative wholeness pattern fitting processes for continual harmonious integration of all the biological and mechanical interacting systems. Position servomechanism system analysis for stabilizing the KESTS structure is one such application; some others are connectiveness systems from the KESTS both to the rotating earthsurface and to the Orbiting Habitat Rings, and space colony habitation systems analysis.
4. To achieve the overall project in enough of a near-future time frame to preserve the earthsurface ecosystem adequately for restoration, common human functionality improvement technologies will need to be quickly provided to all people on the planet to enable the efficient use of human resources in nearly all forms of human endeavor in the creation of KESTS and mostly for the Orbiting Habitat Rings. One such existing technology for enabling an individual to efficiently harmonize self toward chosen goals has been well developed in a form known as "Educational Kinesiology".[11]
5. Corporate industrial business harmonization systems need to be developed. Existing processes

such as Methexis, and Organizational Psychosynthesis need to be explored as possible ways to galvanize the worldwide business processes efficiently enough to achieve the overall goal without getting in each others' way.[12]

Relation to Major Mission Objectives

1. Considering the major mission objective as being the enablement of a thriving expanding civilization while also restoring the earthsurface ecosystem back to health balance, KESTS appear to be the only transportation system adequate to the task of physically moving the bulk of civilization into earth orbit.

2. Makes possible the efficient large scale cargo movement from earthsurface to space for SSPS construction and for assembly of very large spacecraft in earth orbit, and for easy supply of space-derived resource materials for earthsurface replenishment.

3. Enables efficient transportation partway for especially obnoxious earthsurface civilization garbage (such as PCBs, CFCs and radioactive residues) disposal by launching into the sun's solar furnace.

Previous History

1. Some examples of early forms of kinetically supported structures are balloons and pressure-supported spacecraft fuel tanks, the arch of a water fountain, and the cowboy's lariat's lasso tossed over a steer's head.

2. The basic concept of a tower which reaches from the ground up into the sky has been around for a long

time. The ancient "Tower of Babel" at E-Temen-An-Ki was intended to be sufficiently high as to enable man to reach the heavens.

3. The general idea of extremely long space transportation structures was foreseen as tether tensile structures, such as the geosynchronous centrifugally-supported earthsurface tether first proposed by Artsutanov in 1966, and the lunar-through-L1 transportation tether proposed by the author in 1972. These would have been structures which were primarily experiencing tensile forces, in contrast to the primarily compressive forces upon KESTS.

4. In the mid 1980's, Rod Hyde of LRL proposed "Starbridge", a vertical electromagnetic fountain mass stream of beryllium disks from earthsurface to orbital altitudes, calculating that it could lift the combined mass of the entire world human population into space while consuming the electrical power equivalent to that which the city of Los Angeles consumes in only two weeks.

5. Also in the mid 1980's, Keith Lofstrom proposed the "Launch Loop", a kinetically supported structure for lifting spacecraft above the atmosphere for more efficient launch there. It would have used a stretchable continuous linked chain instead of a mass stream.

6. And also in the same time frame of the '80's, Earle Smith proposed a continuous chain form of kinetically supported structure which connected between earthsurface equatorial sites to Geosynchronous Earth Orbital altitudes.

7. The generalized concept of kinetically supported transportation structures which could be also used as electrical power transfer linkage from space to earthsurface was begun and placed on public

accessible computer network files starting in 1988 by the author, while attempting to restore the concepts of Hyde, Lofstrom and Smith to public attention. He continued to develop the general concept such as by adding the concepts of KESTS emplacement by "microelevator" and other new emplacement means, laterally coupling counter rotating pairs of mass streams, powering the KESTS transportation structure by attaching solar-electrically driven mass thrusters to the KESTS in space, and using KESTS to enable migration of civilization into earth-circling Orbiting Habitat Rings for its indefinitely thriving expanding civilization while enabling the restoration of earthsurface ecosystem healthy balance.

Key Demonstrations Required

1. Demonstration of a basic electro- magnetically coupled discontinuous mass stream counter rotating laterally coupled pair supporting its evacuated tubing and coupling lift energy to model vehicles riding the structure.

2. Demonstration of eager willingness of mankind in general to cooperatively continue on into the future with a thriving expanding civilization while also restoring the earthsurface system to health.

3. Demonstration of successful systems research in a test space colony in LEO which has an earthsurface normal equivalent interior environment, developing adequate ways to harmonize the myriad interacting biological and mechanical systems; this is necessary to prove out the long-held assumptions that artificial habitats in space can provide ecologically balanced environs for civilization's social-agricultural-industrial indefinitely long exuberant survival.

4. Demonstration of a surface-to-surface KESTS spanning several miles, carrying manned vehicles.

5. Demonstration of emplacement of a small tube diameter KESTS temporarily reaching Low Earth Orbital altitudes.

6. Demonstration of emplacement of a small tube diameter KESTS pair linking the equator with Low Earth Orbital altitudes. Then out to Geosynchronous Earth Orbital altitude, 22,300 miles up.

7. Demonstration of successful bootstrapping construction process upon the original small tube diameter KESTS out to orbital altitudes.

8. Demonstration of efficient materials transportation from the lunar surface to site of Orbiting Habitat Ring, such as by lunar KESTS, mass drivers, gravitationally-pumped cycling lunar-earth Skyhook, and/or elevator tether through L1.

9. Demonstration of aggregate KESTS capacity to transport people and their household goods from earthsurface at 1 billion people per year, a rate adequate to move nearly all of humanity (7 billion people) into the OHR within a 7 year time span.

Comparison with Tether Types of Transportation

Kinetic Energy Supported Transportation Structures ("KESTS") perhaps will be eventually supplanted by centrifugally-supported equatorial tethers, for long-term massive transportation between earth surface and near-space. Indeed, KESTS might well provide the immense payload lift capacity to GEO useful for the construction materials for such tethers. However, there are several significant advantages KESTS have in the

near future time frame: first, they do not need development of carbon monofilliament (diamond monofilliament) tether material before construction; second, they do not need to be built starting at GEO; and third, perhaps most importantly, they inherently distribute the transportation energy needed to move payload along their length.

Milestones

1. Milestone one is the successful fabrication and operation of working models of KESTS which incorporate all of the functions needed by full scale KESTS. At the present time, work needs to be done in envisioning potential capabilities and associated side-effects, such as contemplated by this paper. Right now a lot of work could be done in mathematical analysis of suborbital mechanics and engineering design, primarily electromagnetics and materials technology, with electronic servo concepts readied for use in automatic adjustment due to varying loads along the length of the KESTS. Modular components need to be somewhat standardized providing a small stream size as is practical, and providing for bundling many of these small ones to provide the higher carrying capacity of the application. Enough technology needs to be developed to build demonstration functional models for people to look at and touch, perhaps ride upon.

2. Since the primary need for KESTS technology is to enable the Orbital Habitat Ring's existence and the transportation of a great number of people and their belongings to it, perhaps the most difficult milestone is when humanity realizes there is a choice., and chooses to “go for the gold”. Change, in general, is stressful, even change for the better. In the short run, it seems easier to let things roll the way they are going, just let things slide. The aggregate stress of change is almost

beyond comprehension, of a world full of people leaving their homes, their homeland, to go live in artificial cities in earth orbit, even to idyllic homes. We each identify with our land, our homes, our cars, all of which we have invested so much of our life to acquire. In the Orbital Habitat Ring, all the land is all new, manmade with the help of robotics, not the land of our forefathers. The homes there are new, we can move our household goods but not the walls of our homes, walls which may have been built by one's father. Even cars have no place in the OHR except in museums, because in each 10,000 person toroidal sub-city, nothing is more than a mile away; other sub-cities are reached by monorail linking the entire OHR together through their hubs.

Yet the choice is not of avoiding major stress, but of which stressor to accept. Looking back the other way, where the limits to earth surface population growth were passed very long ago, requiring some 9 people out of 10 to just... not be... anymore, for long term survivability of humanity, surely is stressful; the process of deciding who lives and who does not, seems likely to be stressful, if not even gladiatorial. Colosseum, anyone? What percentage of resources can be recycled, each time around, and how many recycles can there be before there is not enough left to recycle one more time? Can technology eventually enable 100% recycling? We don't seem to be able to stop ourselves from exterminating species as part of our harvesting of planetary resources, anymore than we can stop from spraying our homes with insecticide, there is no harmony seemingly within us for co-existence anymore with the biodiversity complex that provided us with life. Will humanity realize quickly enough what the meaning of “fittest” is for humanity, in the phrase “survival of the fittest”. Who wins in the long run, the one who stomps on the bee fearing a bee sting, or the one who enables the bee to gather honey

and pollinate the crops? In what way can the average person's attitude be shifted from a tremendous resentment at the prospect of an enormous interference with their daily lives and current property ownership, to that of perceiving a series of wonderful opportunities?

So the second, and perhaps the most difficult and unlikely, milestone to be passed is the one where somehow a world full of people together choose the path of full responsibility for the fragile ecosystem of their Mother Earth, acknowledging their heavy foot upon it, and also simultaneously accepting full responsibility for the tremendous magnificent civilization that can soon evolve from the present one, just shifted up into space orbiting the earth.

1. The third milestone is the actual proving out of the concept of nearly self-sufficient artificial large habitats in space, the demonstration that the complex intertwining mechanical, biological and sociological systems can harmonize fully adequately. Pre-assembled sections of a 1,000-person toroidal research space habitat design are put into low earth orbit by the creation of a flyback engine/control type wet launch module vehicle technology, using the existing proven technology base used by the Space Shuttle. The wheel-shaped space habitat is first built on the ground in the form of pre-fitted modules linked in a circle. The design of each module is for dual use, the other use is for being the fuel tank and payload of an unmanned engine & control module which launches them into low earth orbit. The unmanned engine/control module flies back to the launch site for the next module's launch, much as the present space shuttle returns to the Earth's surface. Use these unmanned wet-launched pre fitted modules to build artificial gravity space stations made of circles of these linked modules to prove out the hypothesis that earth surface gravity and

atmospheric pressure in a rotating toroid can provide functional stability in a group living situation which includes other life forms in a harmonious synthesis. [4]

2. The bulk of the physical structure to be built in the Clarke Belt around the Earth would need to be built out of space resources. The Moon is handy and has plentiful resources of such materials as aluminum and titanium. This material needs to be moved from the Moon's surface to the vicinity of the site for the Orbital Habitat Ring,, perhaps the Clarke Belt, efficiently and with a minimum of pre-industrialization of the Moon. Investigate forms of materials-pumps utilizing the greater depth of potential energy of the adjacent earth's gravity well, to lift materials up out of the Moon's gravity well. One way to do this is to store the energy as angular momentum: an Earth-Moon two-body orbiting Skyhook one-direction materials pump, which picks up packaged payloads from the far side of the Moon on a tether, payload and spacecraft tethered whirling together around their common center-of-gravity as they continue around the Moon and into Earth's gravity well, the spacecraft regaining its energy through appropriately timed release of the payload from a lengthened tether deep into Earth's gravity well. This concept draws from Hans Moravec's creation of the spinning skyhook concept. Lunar mass drivers, and lunar elevator tethers through L1 are other technologies worthy of consideration for this purpose.[5,8,17]

3. Creation of KESTS surface-to-surface bridges to develop the technology into a high reliability system, while also providing new modes of long range transportation of large amounts of fuels, water and other resources. Development of emplacement techniques. [5,6,7]

4. First Orbital Habitat Ring 10,000-person space settlement built from Earth materials, brought up on a KESTS bridge. This develops the functional structural design with components built comparatively easily on the Earth's surface. Outfitting the interior of the space settlement to include as many earth-normal features as possible. Tests out agricultural systems, condominium homes on the interior slopes, and creative stable harmonious social system...and millions of the other necessary things needing to be tested out there too. In a detailed reference design of the 1970's, each colonist effectively has 26 fish, 6.2 chickens, 2.8 rabbits, and 1/7 of a cow, and the plant diet for these animals is grown on the habitat in lunar soil about 1 foot deep. Housing of the colonists is on terraced condominiums along the sides slopes inside the rotating wheel habitat, including 45 square yards per person for residential and community life, 5 square yards per person for mechanical and life support systems, and 21 square yards per person for agriculture and food processing.[9]

5. Long term electrical power to support the kinetic energy bridges needs to come from space resources instead of relying on Earth resources. Dedicated SSPS in GEO is one possibility; solar- electric mass stream thrusters hanging on KESTS is another possibility. Thrusters would use solar energy converted into electrical energy to accelerate the downward direction of the kinetic mass stream so as to replenish the energy consumed by the support of the bridge structure and for moving payloads along it. The thrust of that acceleration would be against the weight of the power converter, being located along the bridge at points below synchronous orbit.[7]

6. Demonstration of adequately shielded space habitat at the earth orbital altitude selected for the Orbiting Habitat Ring.

7. If a site for the Orbiting Habitat Ring civilization is selected below GEO, then demonstration of adequately efficient reliable cargo transfer linkage between the relatively moving KESTS and capsules circularly orbiting the earth at that altitude.

8. Successful full-size fully functional habitat built on site in earth orbit from construction materials brought up on KESTS, such as a 10,000-person toroidal design.

9. Robotically-built basic habitat shell structure made on site at OHR altitude out of lunar materials.

10. Interior outfitting of an Orbiting Habitat to provide a standard of living sufficiently better than typical of earthsurface living conditions to easily attract early settlers.

11. Sustainable construction rate of 300 orbiting habitats robotically-built per day in the OHR from lunar/asteroidal raw materials.

12. First million square kilometers of earthsurface restored back into pre-civilization ecosystem state.

13. Construction/population of second Orbiting Habitat Ring, populated by 7 billion descendants of first habitat ring's thriving growing population.

14. Complete restoration of the earth surface ecosystem back to nearly pre-civilization conditions, with a rotating population of only 100 million people on the earth surface at any one time, composed of ecosystem restoration and maintenance workers, and national park vacationers.

Applications Beyond Space Development

Before these very large kinetic structures can be built here on the Earth's surface, on the lunar surface, and on the Martian surface, a lot of experience needs to be gained by utilizing them for smaller spans in surface to surface applications. Kinetic structural arches might support conveyor belts which span hundreds of miles, connecting coal deposits with local electric coal-fired powerplants. The kinetic arches could support water pipelines spanning from arctic glacial areas to deliver water to desert farming areas thousands of miles away, along great loops created by the coriolis force. Oceans could be spanned, directly linking the continents, analogous to the building of bridges where ferries were the only option before.[15]

Ground-to-ground applications would provide the development of the technology, and supply solid working experience with KESTS. The technological niches appear to be in possible competition with long range air and sea transportation routes. The specific forms of KESTS technology actually put into hardware will control the ultimate range of applications, of course.

Next, a full-scale over-water bridge could be built, perhaps linking two islands or an island with the mainland, such as connecting Long Beach with Catalina Island, some 27 miles of water to cross. Early ones will fail, just as in aircraft and rocket development; the failure modes of KESTS is likely to be fast and spectacular with the stream mass being quickly burned up when suddenly having to travel through the atmosphere without its vacuum shielding, so early ones might best be built in unpopulated areas. What must be done to compensate for coriolis forces will be discovered and proven out. Maintenance procedures and needs would get worked out. An ongoing creative

process of envisioning, design, analysis, experimenting, engineering, manufacturing, trying out...and back to the envisioning function again, forms an endless loop ever perfecting the KESTS to meet real-world needs and resources functionality.

As confidence builds as the KESTS meet the real world environment ongoing, ever greater projects can be attempted. Intercity KESTS bridging remote unpopulated areas might then be built, such as linking a new super airport in the Palmdale area with Los Angeles, a KESTS connecting Hawaii with the California coast and with Alaska also. Other countries would be involved by this time, such as Japan would find KESTS island hopping quite effective in their transportation network. With experience of KESTS in high storm conditions such as hurricanes...assuming their multiplicity of servos is able to compensate for such heavy wind loads...would open up possibilities for transcontinental KESTS transportation. The relative advantages of high kinetic energy flatter trajectories would be balanced with the lower velocity high arching trajectory KESTS. Delivery of materials, such as bringing glacial water to the deserts of Australia, North Africa, and the Middle East, opens up another version of KESTS, where the KESTS primarily provides support for the vacuum tubing, and the materials being delivered are themselves moving in sealed containers at near orbital velocities within the vacuum stream tubing enclosed in a high velocity hose structure that unzips at its delivery terminal, disgorging its cargo, and then is whirled around along with the KESTS stream for the return trip to the inlet terminal.

Other Important Factors

The basic intention of this project is to provide a key transportation link to enable an alternative to the rapidly

increasing resource entropic garbage and destruction of ecosystem biological resources such as rain forests by an expanding earth surface civilization. Recent research shows that the earth surface ecosystem can indefinitely support only a small fraction of the present human population; this project could give those "excess" billions of people some exciting and useful things to do and hopefully in the process create a place for themselves and their children to come to live in an enormously expanding civilization, largely independent of earth surface resources, and enabling restoration of the earth ecosystem thereafter. Probably when the first cave dwellers decided that the cave complex was overpopulated, and cast out the weaker ones, they didn't realize that those "weaker" ones would learn to build their own shelters and grow their own food, and create a population support resource vastly beyond that possible to the cave dwellers in their hunter/gatherer territory. The kinetic structure transportation technology just might be able to open up the potential of truly vast real estate creation in the Clarke Belt. There civilization could flourish given the efficient inflow of raw materials from both earthsurface and lunar sites.16

The technological challenges are great. The beneficial applications are vastly greater. Who will do the R&D? Who will pay for the R&D, and how will the rights for the use of the resulting technological development be kept accessible for all humanity, yet pay for itself in a reasonable period of time? Indeed, KESTS to Orbital Habitat Rings would require a technological resurgence of worldwide activity of science, technology, social, agricultural, environmental fields ... nearly all of the fields of human endeavor.

Some Research Questions

1. Stability of the KESTS structure: how high can it go

while remaining able to cope with unbalanced transient forces upon it? What are those expected forces? How much wobble will be present at any point along it, particularly at the site of embarkation to the habitat ring? Can its active position servo system be adequately damped to prevent uncontrolled oscillations in the feedback loop? What is the ratio of active feedback damping vs. energy-consuming passive damping structures distributed along KESTS?

2. What is the traffic volume necessary for a given size KESTS, at the break-even point, considering the energy input required just to maintain support of the structure? Analogous to the heart beat pumping blood through a person's arteries, capillaries, and veins, that "pumping" is required to sustain life of the KESTS system.

3. Pulsing magnetic fields hazard to living beings: The coupling of the mass stream to the enclosing tube structure and to vehicles moving along the structure is primarily pulsing electromagnetic in nature. What hazard does this present to passengers, since some studies have linked such ELF fields to diseases such as alzheimers and leukemia; can design minimize such ELF fields in cargo and passenger parts of the vehicles?

4. What kind of industrial business system can possibly remain responsible to the long term goals of an expanding civilization and restoration of the earth surface ecosystem?

5. Willingness of the majority of present-day earth surface population to leave their lifelong homes to migrate to the orbiting habitat ring: people are attached to the familiar, and often have worked much of their lifetime to provide the home they now live in with their

family, and are not likely to easily choose to leave it all. The value of their real estate will need to be adequately returned to them somehow in the overall process. And those whose fortunes are dependent on the real estate wealth they have currently amassed, will need assurance of equivalent wealth in the new civilization site somehow. Who will provide the money for all this? Can there be a one-for-one correspondence of real estate on the ground with real estate in the habitat ring? And can life in the habitat ring be guaranteed sufficiently better than that on earthsurface to provide the incentive to migrate?

6. Can there be multiple KESTS, or would the crossover sites provide risk of crashing together in space? Can these crossover points be made deliberately coupled, even providing additional stability to the overall KESTS system?

7. What orbital altitude will be the optimum site for the habitat ring? The Clarke Belt (geosynchronous earth orbit) would provide a theoretically stationary embarkation point between KESTS and the orbiting habitat ring, but shielding requirements might be greater there than in other places, requiring more non-rotating shielding mass around them. Low Earth Orbit would require less shielding, and the demands on KESTS are much less, but guarantee of indefinitely long compensation for orbital decay of the immense habitat ring would somehow need to be made. And is there some way to have habitat rings at both altitudes, using mirrored KESTS to arch over lower orbital altitude habitat rings?

8. What effects of the mass stream's electromagnetic flow within the earth's magnetic field?

9. The entire KESTS structure must rotate once every 24 hours, as it is attached solidly to the earth surface. Lateral coupling between upward and downward mass stream provides the mechanism to swing the enclosed mass streams around with the rotation of the earth, but what are the magnitudes of the distributed lateral force between the mass streams and tubing, and how much weight does this structure add to the KESTS? These are important parameters for KESTS equations.

10. Given the transfer of most of most of civilization to the Orbital Habitat Rings around the Earth, 15 billion people in the hypothetical example given here illustratively, there would be plenty of spare mile-diameter 600 feet wide toroidal habitats, which could be used to re-create small copies of earthsurface natural ecosystems. Those local zoological parks conceivably could be ark-like backups for all of the original earthsurface species, including the largest land and marine mammals. Those space-based zoological gardens would be excellent research sites for the restoration and maintenance of the giant national park that the earthsurface could become, preserving precious biological genetic resource pools of biodiversity for the future. What will be the managerial processes that ensure this will happen?

Conclusion

The engineering, sociological, and business challenges of KESTS to an Orbital Habitat Ring are great; indeed, in nearly all fields of human endeavor. The transportation structure itself has engineering challenges enough to satisfy the most dynamic intelligent of people, not the least of which is engineering the dynamic stability to cope with potentially oscillatory mechanisms due to the long delay times between load changes and time to reach the site

from the mass stream re-initialization point(s). In the Orbital Habitat Ring, there is a major challenge of balancing the myriad interactive systems of life and machine for stability, yet including the creative growth necessary to civilization.

KESTS concepts suggest to us a new way to move ourselves and our civilization's belongings far and high into earth orbit, perhaps even enabling earth life to occupy the relatively motionless orbit of the Clarke Belt. To leave the caves of earthsurface while we can, or not to leave; that is the question. Continue to ride the earthsurface ecosystem downward, or to turn upward? Every one of ourselves, not just the lucky few, can thereby move up to an area where it is more appropriate to build ideal man-made living space. Up there, mankind can flourish like never before, and from there can allow Mother Earth to heal herself, as if from the partition as she gives birth to mankind bringing life to the rest of the solar system. The decision to research and develop the technology of kinetic energy supported electrically powered transportation structures would be a major step toward true large scale colonization of space, even in our time.

References

1. Hyde, R.A., Starbridge: Earth to Space Transportation, Silicon Valley Chapter of the L5 Society, Lecture, 1984
2. Lofstrom, K.H., The Launch Loop, L-5 NEWS, 8-9, Aug 1982
3. Smith, E., The Texas and Universe Railroad, L-5 NEWS, 9-11,1985
4. Cline, J.E.D., Wet-Launch of Prefab Habitat Modules, Space Manufacturing 10, Proceedings of the 12th SSI-Princeton Conference, 88-91, 1995.
5. Cline, J.E.D., Testimony given to the National

Commission on Space, Nov. 14 1985
6. Cline, J.E.D. (J.E.D.CLINE1), Space Inspiration, GEnie Space and Science Library file # 475, 1988.
7. Cline, J.E.D. (J.E.D.CLINE1), Kinetic Structures III, GEnie Space and Science Library file # 2466, 1992.
8. Cline, J.E.D. (J.E.D.CLINE1), Longtrans 2, GEnie Space and Science Library file # 927, 1989.
9. NASA SP-413, Space Settlements: A Design Study, 1976
10. Cline, J.E.D. (J.E.D.CLINE1), Hwy To Earth GEO Ring, GEnie Space and Science Library file # 747, 1989.
11. Dennison & Dennison, Edu-Kinesthetics In-Depth: Advanced Workshop, Edu-Kinesthetics, Inc 805-388-9898, 1990.
12. Patterson, E.T., Methexis & Extraterrestrial Medicine, Space Manufacturing 10, Proceedings of the 12th SSI-Princeton Conference, 167-181, 1995.
13. Cline, J.E.D. (J.E.D.CLINE1), KESTS Emplacement 2, GEnie Space and Science Library file # 1974, 1992.
14. Myrabo, L.N., Technological Evolution of Manned Microwave-Boosted Spacecraft with Hyper-Energetic Transatmospheric Performance, Space Manufacturing 10, Proceedings of the 12th SSI-Princeton Conference, 71-87, 1995.
15. Cline, J.E.D. (J.E.D.CLINE1), Earthbound KESTS, GEnie Space and Science Library file # 953, 1989.
16. OíNeill, G.K., The High Frontier, Space Studies Institute Press, 1989
17. Moravec, H., A Non-Synchronous Orbital Skyhook, The Journal of the Astronautical Sciences, Vol. XXV, No.4, 307-322, Oct-Dec. 1977.

Here is one of three papers presented by the author at the Space Engineering and Science Institute's conference at Albuquerque, NM in 2005, and printed with dual-use copyright in their conference proceedings, pp.230-239; except in that volume the paper's submitted graphics were somehow “un-grouped;” but the graphics in this book are correct.

The Space Escalator Carousel's Unique Potentials

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Abstract. The Space Escalator can be designed to be scalable from micro scale to whatever great capacity is needed to do the tasks. Very different from the anchored tether Space Elevator, it would be independent of super strength to mass ratio tether material availability. Although stretched into a huge 131,300 Km perimeter loop around the Earth, approximating the shape of an Orbital Transfer Trajectory from the equatorial ground level up to Geostationary Earth Orbit above the opposite side of the planet, its basic conceptual complexity level is similar to the common CD drive with its data controlled combination of rotary and linear synchronous motor functions. The spacecraft would ride this space escalator from ground to GEO by electromagnetic drag against the rising sides of continuously flowing high velocity electric motor armature mass streams, which has its velocity set to be somewhat faster than that needed to provide the centrifugal force, above orbital transfer velocity, to produce the confined outward force that would just balance the force of gravity on the immense loop structure's mass with its loads. Electromagnetic synchronous mass accelerators at the ground terminal replenish the energy consumed by lifting payload and internal power usage by the inductive magnetic levitation track system the armatures slide along at high velocity, and for powering the position servo system. Contra-rotating armature mass streams flow in laterally coupled tracks to balance forces, along a cycloid path as the planet rotates.

1. Purpose

If there were a wise guide overseeing the development of civilization, it could well look as if civilization was rapidly both outgrowing its resource base and also has reached a technological capacity to extend civilization into the vast resources of the solar system, hopefully before the implosion of civilization cannot be halted. To that hypothetical wise guide, this paper offers a conceptual outline of a way to efficiently move materials and personnel between the earth surface and high earth orbit, continuously and at high volume, electrically powered, an optional alternative to anchored tether space elevators, thus embodying a different set of operating parameters. The GEO environment could be tamed and its unique qualities utilized to build a large extension of civilization there, given time; a high place from which to reach out with reaction engined vehicles to the Moon, Mars, asteroids and beyond; and perhaps the reaching down to repair a ravaged planetary ecosystem.

This is a conceptual design for electrically powered transportation structures operating between the equatorial Earth surface and Geostationary Earth Orbit, a place chosen because things stay there when put there, no booster needed. And to provide alternative bridging structure concepts not requiring superstrength tether materials and the associated characteristics of anchored tether space elevators, yet having its own characteristic challenges.

Not just for putting adequate Satellite Solar Power Stations (SSPS) into GEO before we have burned up our petrochemicals and poisoned the atmosphere too much in the process, to preserve an expanding thriving worldwide civilization; but also to enable solar powered mass-charge ratio separation solar powered total recycling plants built and used in GEO to deal with the problem of toxic industrial

materials and spent high entropy products; to move reaction engine spaceports up to GEO which is 91% up out of earth's gravitational energy well; and even building a few Stanford Torus inspired passively shielded cities in space in GEO; all before major access to lunar and asteroidal materials become widely available there. Potential energy costs are in range of a few dollars per kg lifted from ground to GEO, key to the applications and expansion of civilization into high earth orbit, potentially within the relatively near future.

2. Coping With Incredulity

The idea that a railway-like device could exist as a huge hoop encircling the Earth could be incomprehensible, especially to a mind accustomed to reaction engined launch vehicle access to space, struggling to comprehend how a railway could go up all the way to GEO, being aware of the limits of existing tall buildings and towers. Common sense would indicate that limits on the compressional strength of materials, and the positional instability at the top of very tall thin compressional structures, appears to put a ceiling on how high one can build, and that limit is nowhere near "space", although compressional metal structures pressurized internally could conceivably go up tens of miles.

So, perhaps a loop railway-like device can be initially comprehended by imagining an equatorial plane Earth orbital altitude being completely occupied by a rope, or even a thin stream of nonvolatile liquid, which is rotating around the planet at orbital velocity; then shift it from a circular to an elliptical orbit, compensating for the changes needed, until the elliptical orbit grazes the earth's equatorial surface and cycloidialy swings around synchronous with the Earth's daily rotation, thus forming the basic structure from ground to high in

space, even up to GEO. Those "compensations", such as for the meteoric velocity as it streams through the Earth's atmospheric part of the path, and for the differences in velocity along the elliptical orbital path, are what some specific technological coherent configuration provides. Figure 1 illustrates the next step from there, that of bearing loads.

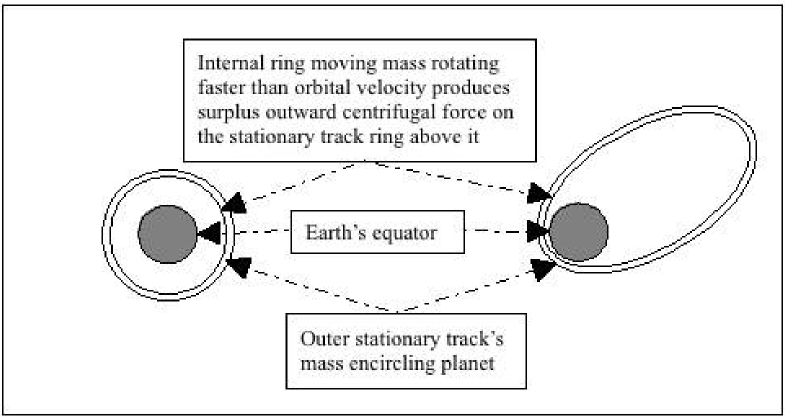


Figure 1. Visualization of imaginary experiment illustrating the upward supportive force on a stationary ring by an orbital ring sliding along beneath it faster than it's altitude's orbital velocity; then transferring to an elliptical structure.

3. A Basic Technical Consideration

It may be useful here to examine some basic positional change forces in such a dynamic system. The moving mass of an armature segment exerts a force on the track when the track deflects its path, as illustrated in Figure 2.

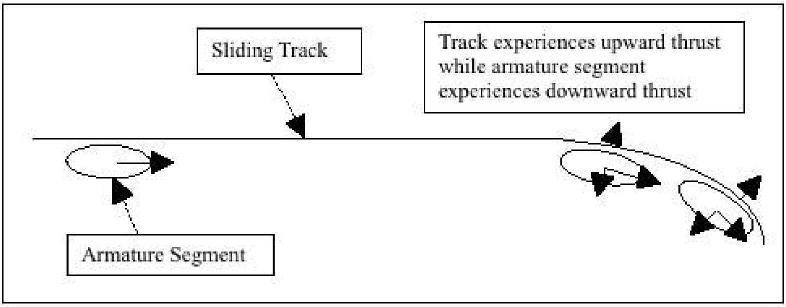


Figure 2. The moving mass of an armature segment exerts a force on the track when the track deflects its path.

4. Basic Complexity and Functionality of the Space Escalator Carousel

Very unconventional to today's Aerospace and even to anchored tether space elevators, the Space Escalator Carousel would have a conceptual complexity level very similar to the common CD drives found in today's computers, with its data-driven synchronous linear and rotary electric motor functions. Although few of us fully comprehend every part of that common CD drive in our computer or car, it is clear that they can be made and sold in large quantities: they work. The much larger perimeter of the Carousel, however, would resemble the 131,300 Km loop of an Orbital Transfer Trajectory between equator and GEO; and the axle bearing function would be provided by armature segments sliding along magnetic levitation tracks throughout the structure’s extent.

The servoed linear synchronous motor function would be utilized by the mass stream electrodynamic inductive drag lifting of the spacecraft up along the carousel structure from the ground up to GEO, and gently return back to the ground while reclaiming much of the spacecraft mass energy. It would also be used for fine-tuning the position of the structure, by

differential drag across the girth of the structure.

An electric motor has electrical energy input, and outputs mechanical energy, the movement of mass, as its output: just what is needed for access to high places, including space. An electric motor takes its input electrical power, converts the power into currents, electric and magnetic static and dynamic fields, interacting with preexisting magnetic fields within itself, becoming momentum and centrifugal forces within itself, store energy within its electromagnetic fields and kinetic energy centrifugally outward, and lifts spacecraft by upward inductive drag of relatively moving parts, and can output both kinetic and electrical energy distributed around itself. These are all useful principles when one considers the basic functions of moving mass between the earth and space. The outward-from-center centrifugal force created within the rotation of an electric motor, projected upon an electric motor perimeter encircling the planet, utilizes the outward-from-planet centrifugal force to oppose the force of gravity on the components of the electric motor perimeter. The velocities involved need to be hyper orbital transfer trajectory, the excess velocity appearing as outward centrifugal force and chosen to slightly exceed the force necessary to balance the force of gravity on the stationary parts of the structure with its loads, including the mass of the spacecraft moving along the structure.

Those hyper-orbital-velocity motor moving parts are conventionally called the motor's rotor or armature. Since there is exchange of kinetic energy with potential energy as the armature mass rises and falls in its circulation around the planet circulating between ground level and high earth orbital level, the armature's density within the structure must vary correspondingly. This would be accomplished in this configuration by making the armature into a large number of discrete chunks of mass with embedded permanent magnets

and their portion of magnetic levitation sliding surfaces; and the synchronous nature of the electric motor provides the separation between the armature segments, each of their positions in constant definition within a certain range that is less than their minimum separation as they flow as mass streams within the structure around the planet.

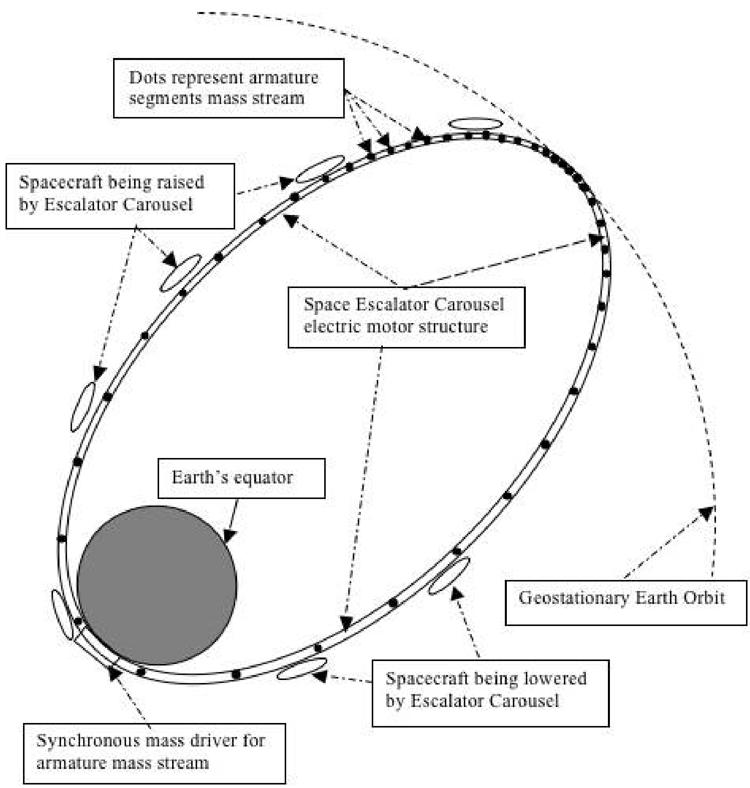


Figure 2. A Space Escalator Carousel around the Earth up to GEO, showing armature mass stream segments and captive spacecraft.

Those armature mass streams flow around the planet along magnetic levitation tracks which are part of the stationary part of the perimeter electric motor, which would be somewhat shaped like an Orbital Transfer Trajectory which has its perigee at the radius of the earth's equatorial surface, and apogee at the altitude of Geostationary Earth Orbit, as the whole structure also rotates with the planet. The stationary part of the track structure encloses a hard vacuum environment for the movement of the high velocity armature segments while traveling within the earth's atmospheric portion of the path. Again, their outward centrifugal force against the structure is what supports that stationary part of the structure with its loads.

Counter-rotating sets of mass streams would provide balance to their gyroscopic precession, and provide for upward-moving mass streams in all parts of the quasi-elliptical structure, available for some positional control of the structure to compensate for wind loads and differential spacecraft loads.

The sets of mass streams would have their paths defined by a track structure, necessarily of a magnetic levitation type that inductively functions at velocities up to 40 Km/s. A sliding armature energy-momentum transfer technology needs to be developed for servo-modulated exchanges of kinetic energy with positional change forces and electrical energy throughout the extent of the transportation structure, operating in a vacuum at high velocities.

Electromagnetically coupling also exchanges momentum along the structure, as the spacecraft moving along the outside of the stationary structure couple into the momentum of the rising sides of the sets of counter-rotating armature mass streams flowing within the structure, lifting them from ground to GEO where they deposit their payload of people and materials for construction in GEO, such as Satellite Solar Power Stations; then gently returning those

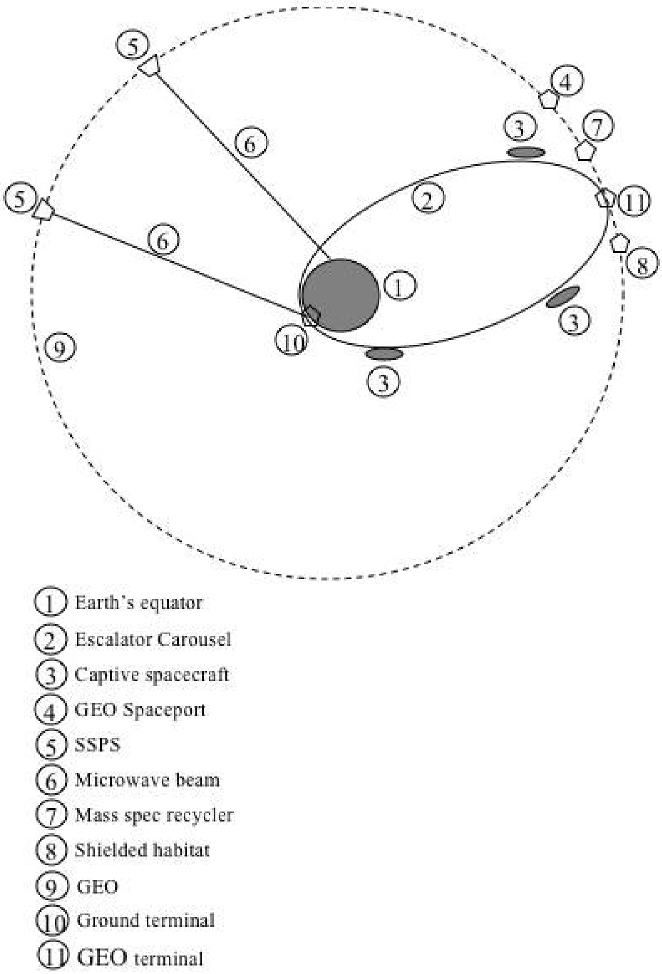


Figure 3. Overall shape of the transportation structure around the earth, along with some of its important applications it could enable construction in GEO

spacecraft back to the ground with fresh payload from space processing and eventually items made from lunar and asteroidal resources, brought back by reaction engine powered spacecraft utilizing spaceports built in GEO.

Note that the armatures, constrained to the shape of the structural track shape for their path, are not in a free orbital motion, not at all in free fall, although a component of their rising and falling motion is so. And that the armatures travel along tracks within paired opposite directions, so as to have rising tracks everywhere along the structure for lifting payload and servo positioning fine tuning of the structure's position, and their lateral coupling via the stator structure balances gyroscopic precession.

Looking at any small section of the motor structure, it looks and acts like a synchronous linear motor; yet looking at the structure as a whole, it is a synchronous rotary electric motor, without an axle, of course.

The overall escalator motor system has electrical energy delivered to it at the earth's surface terminal via synchronous electromagnetic drivers, has the energy stored as kinetic energy of the armature mass streams, which is delivered to the lifting of spacecraft and their payload along the structure from ground to GEO, along with energy consumed by the fine tuning of the structure's position in space and within the high velocity inductive magnetic levitation track system. The contra-rotating mass stream sets flow in laterally coupled tracks to balance gyroscopic precession forces, and the armature segments travel in a cycloid path as they flow around the rotating planet.

There also is potential for direct solar-electric power input along the structure, by solar power plants balancing their weight below GEO, alongside the motor structure, by thrusting against the downward moving armature mass streams, analogous to a rocket hanging

motionless above the earth, its weight supported by thrust on reaction mass, which is the armature mass streams in this case. There could be a vector component which is not downward, but provide a lateral push to the structure, useful for position refining of the structure, and eventually for providing energy from the structure to replace orbital decay energy of structures in GEO, especially if eventually GEO becomes completely infilled with linked cities in space, each built such as like the passively shielded Stanford Torus design of the 1970's, for example.

Although the initial Space escalator Carousel structure is likely to be built using an east-west tunnel through the Ecuadorian Andes mountains as its ground terminal site, there is potential for building paired Space Escalators from land sites mirrored across the equatorial plane, pressing against each other where they meet in GEO, enabling space access from non-equatorial sites, for example, USA's Maine at one site, and Argentina's Comoros at the other ground site. This would ease the logistics of interconnecting GEO with higher latitude nations' ground transportation systems. Clearly, these need to be ultra-reliable structures by that point, and equatorial non-mirrored Space Escalators would be the surface connection points to develop from, to simplify variables during early developmental stages of large scale coupling of civilization into the vast resources of space, its endless solar energy, materials obtainable from lunar and asteroidal sites, and vast room to build and grow.

Major technologies needing development for the space escalator are the sliding armature energy-momentum transfer technology, including the magnetic track technology for sliding the armatures traveling within a hard vacuum environment at up to possibly 40 km/s; and the electromagnetic coupling systems that synchronously input energy at the earth surface terminal site, and extract electrical energy and couple

momentum all along the structure as needed.

The design needs to provide for bootstrap scaling of the structure up to full capacity girth, starting from the millimeter-girth needed for relatively low cost and risk during emplacement tries of the "seed" structure, and for the eventual orderly dismantlement and component recycling of the original structure; for the ground-coupled push on a full ring of GEO space habitats to prevent orbital decay collapse.

7. Seed structure emplacement

The “seed” micro cross-section structure will probably take many tries before ready for scaling. Designing it for a primary loop with two contra rotating mass streams to each side, is minimum seed structure, so that equal mass counter-rotating mass streams exist and laterally balanced for precession control. It could be all the way to GEO; or with an accordioning technique useful for bringing it down deliberately, and re-raising it from ground site stacked sections, and could be to Low Earth Orbit or even stay in atmosphere, flotation supported.

Envisioned erection techniques, at this point, for initial structure include the ground terminal site, such as in an east to west tunnel through the Andes mountains on the equator, de-spooling of a millimeter-diameter tubetrack carrying above orbital velocity micro-armatures within in one direction, which flow through the tube trackway along its curve providing support of the trackway’s weight, then when striking the end of the rising structure, is bounced mostly backward such that it provides a forward thrust to the top end of the tubeway, servo directed to guide it into the approximate final Orbital Transfer Trajectory shape until encircling the planet back to ground terminal site where it must somehow quickly be locked into the start of itself; or instead to meet with a version of itself having gone the

opposite direction around the planet, and sliding linked together for the remainder of the journey around the planet back to the ground terminal site. Clearly, this would take multiple tries until one time works. Another way is to take inspiration from Smith's Texas railway technique, to use air floatation to support a seed structure around the planet; once the stator has been so emplaced, armatures could be fed into it at high velocity from the ground terminal's mass drivers to enable the structure support itself dynamically; then within the east-west equatorial tunnel ground terminal site, evacuated facilities underground there to add sections of tubeways and incrementally increase structure perimeter until reaching Geostationary Earth Orbit access size. This latter technique provides insight for a full scale structure's gradual pull down from GEO into LEO or even atmosphere, then incrementally restored by adding full scale sections within the construction hard vacuum tunnel site.

8. Construction to scale to operational girth

Recalling that the upward force of the armature mass streams supports a static mass equal to the mass of the armature aggregate mass for each multiple of orbital transfer velocity minus one, therefore if the static mass is equal to that of the armature mass (easy to think about) then increasing to four times OTV it can support the static load of a non-running static tube and track equal to double the original static load mass, enabling exponential scaling construction doubling girth every layer added. Each tube track layer completed then gets armature mass stream injected into it and when one circuit time is completed it too then can support next layer of construction load. The optimum ratio between armature mass stream aggregate mass and static tubetrack mass remains to be determined, of

course. Once scaled to an operational capacity, even a temporary one, the armature mass stream would need to be dropped to its normal operating velocity, say, twice Orbital Transfer Velocity. There could be steps in scaling its girth, to allow for use for initial construction materials lift to GEO for initial proto solar power plants and total recyclers, and initial passively shielded habitat facilities in GEO. Then scaling up construction could be resumed.

9. Designing for maintenance and repair in space

A mostly empty tubetrack stator cross-sectional form would both enable more efficient differential lateral force servopositioning by differential mass stream drag, as well as disintegration higher in atmosphere in case of total catastrophic collapse of the structure. Maintenance and repair mechanisms and facilities need to be integrated into the system right from the beginning, such as the ability to pull out all the armatures from any given group of mass streams upon signal that a breach in some of the tubes has occurred, then “handcar trucks” to go out and splice new stator tubetrack sections into the damaged areas, then return the armatures back into the repaired stator tubetrackways. Such maintenance & repair facilities need to be tied into an intense information system linked into every part of the transportation structure, and human interface designed so as to be easily comprehensible for pattern variations.

10. Providing for orderly lowering of the structure

Perhaps it is possible to design the structure so as to be able to dynamically rack up sections of the

stationary structure within the earth surface terminal, coherently shrinking the perimeter of the carousel so as to maintain overall tensile outward bias while all vehicles are offloaded at the ground terminal during the power emergency; when power input is restored, the unracking of structural sections would be begun until it is back up to GEO-reaching size again. If the effective structural density is less than that of high altitude air at this point, and air-excluding tubing continues to surround the maglev tracks, the structure could float in the atmosphere until the emergency is resolved, then the unracking of sections would begin. In fact, this scenario hints at other possible ways for emplacing such a structure.

11. Conclusion

Hopefully approaching the 15.7 KWh/Kg energy efficiency of the actual energy supplied to payload during the lift, intent is to solve many upcoming crises by providing opportunity in clean abundant electrical energy, reducing greenhouse gas, total recycling of toxic and high entropy industrial materials, sustainable economical space resource access, and new room for civilization to grow. The Space Escalator Carousel form of space elevator could provide wholesome new direction to the vigorous drama of people in the flow of civilization.

References

Clarke, Arthur C., “The Exploration of Space“, Cardinal edition June 1954.

Cline, J E D (JEDCLINE1), “ENERGY/TRANSPORT SYSTEM”, GEnie Space Library file #563, 1988 (http://www.kestsgeo.com/pages/geniefiles/g563.html)

Cline, J.E.D. (JEDCLINE1), “Microelevator Vers. 1”, GEnie Space Library file # 578, Oct. 11, 1988 (www.kestsgeo.com/pages/geniefiles/g578.html)

Cline, James E. D. (JEDCLINE1), “HWY TO EARTH GEO RING”, GEnie Space Library file #747, 1989 (www.kestsgeo.com/pages/geniefiles/g747.html)
Cline, J.E. David, “Treehouse Haven”, Meditation Magazine, 1989
Cline, James E. D. (JEDCLINE1), “LONGTRANS 2”, GEnie Space Library file #927, 1989 (www.kestsgeo.com/pages/geniefiles/g927.html)
Cline, James E. D. (JEDCLINE1), “ORIGINAL MOONCABLE”, GEnie Space Library file #1179, 1990 (http://www.kestsgeo.com/pages/geniefiles/g1179.html)
Cline, J. E. D. “A Potential Application of General Systems Theory: KESTS: A Unique Trans-portation Technology Concept & Implications” Presentation to Los Angeles Chapter of ISSS, November 9, 1994. (http://www.kestsgeo.com/pages/issskests.html)
Cline, J. E. David. “Wet Launch of Prefab Habitat Modules.” Space Manufacturing 10, Path-ways to the High Frontier, SSI, AIAA, 1995, 88-91
Cline, James E. D. “Kinetically Strengthened Transportation Structures.” Space 2000 Confer-ence Proceedings, ASCE, 2000, 396-402.
Cline, James E. D. “Kinetically Supported Bridge Vehicle Lift To GEO.” Space 2002 Robotics 2002 Conference Proceedings, ASCE, 2002, 8-21.
Cline, James E. D. “Comments and alternatives, by Jim Cline, regarding the anchored tether Space Elevator project proposed by Bradley Edwards...”, 2002, www.kestsgeo.com/pages/cobetse.html
Cline, James E. D. “Energy Flow in Kinetically Strengthened Transportation Structure Systems to Space” Earth & Space 2004 Conference Proceedings, ASCE, 2004, 859-866.
Hyde, Rod, “The Starbridge Concept” , L-5 Society lecture, Sunnyvale CA Sept. 23, 1984
Lofstrom, K.H., “The Launch Loop”, L-5 NEWS, 8-9, Aug. 1982
NASA, "Space Settlements, A Design Study", NASA SP-413, 1977
Smith, Earle, “The Texas and Universe Railroad”, L-5 NEWS, 9-11,1985

Presentation Slides for “Kinetically Supported Bridge Vehicle Lift To GEO” in 2002

The following are the fifteen slides the author used to present the KESTS to GEO concept at the American Society of Civil Engineers' space conference in 2002 held at Albuquerque, NM. An earlier, shorter, paper on the subject by the author was given at the prior ASCE space conference in 2000, and was the first formally peer-reviewed published paper on KESTS; the following are the slides from the second KESTS paper's presentation, as used in 2002.

Exploring the use of advanced electrical motor technology for rail access to orbit from the ground

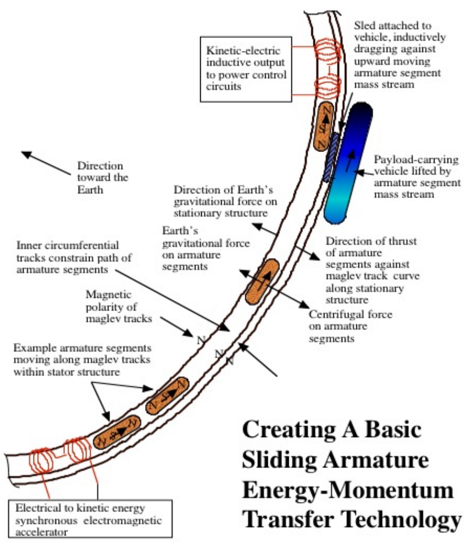
- Bypass the limits of chemically fueled ground launch technology
- Bypasses tensile strength limitations of tether space elevator technology
- Potentially easy and efficient high volume access to orbit from the ground
- Economical lift of large numbers of people to orbit; as well as SSPS emplacement, etc

Electric motors that become transportation lifting bridge structures from ground to orbit

- Building structures that are electric motors which have perimeters so large as to extend from ground up into earth orbit
- These electric motor structures lift vehicles continuously from ground to orbit
- Motor structures that infill OTT ground to GEO shape support their weight by stored kinetic energy centrifugally opposing gravity

Basic Technological Functions to be Explored and Developed

- High velocity synchronous motor magnetic levitation tracks
- The electric motor’s armature mass stream segments
- Vehicular lift by dynamic drag against the upward-bound armature segments
- Absorbing the energy of descending spacecraft & payload
- Compensating for live loads on the structure

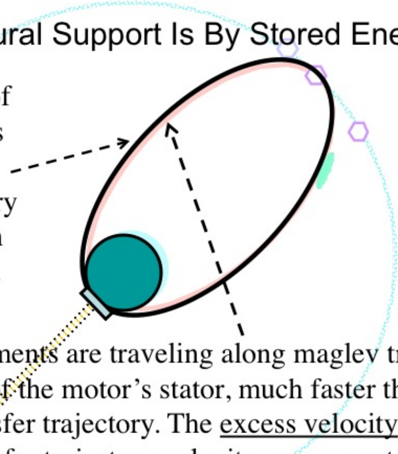


Creating A Basic Sliding Armature Energy-Momentum Transfer Technology

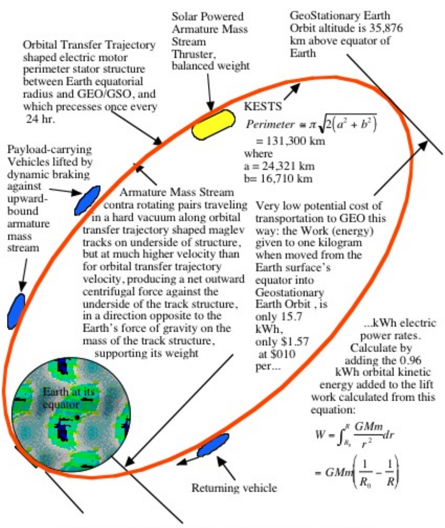
The magnetized armature segments inductively transfer electrical energy and momentum along their paths within maglev tracks, and provide an outward force due to their deflection from a straight path by the curved stator shape, being an upward supportive force relative to the encircled planet.

Primary Structural Support Is By Stored Energy

The basic shape of the motor stator is that of an Orbital Transfer Trajectory between the Earth surface and GEO.



The armature segments are traveling along maglev tracks on the underside of the motor's stator, much faster than for an orbital transfer trajectory. The excess velocity above orbital transfer trajectory velocity presses outward, upward against the weight of the stator with its live loads.



Some Parameters of the Kinetic Energy Supported Transportation Structure (KESTS)

The Orbital Transfer Trajectory shaped electric motor

Infills a perimeter of about 131,300 km, along which it lifts payload-carrying vehicles up to orbit in GEO

The actual *work done to* payload by lifting it from ground to GEO is *only 16 kWh/kg*

- Based on chemically fueled launch vehicle statistics, it may seem impossibly expensive to move payload in large quantities from the ground up to GEO.
- Yet, consider the calculated actual amount of energy added to a mass simply by lifting it to GEO altitude and imparting orbital velocity to it there:
- $W = GMm\left(\frac{1}{R_0} - \frac{1}{R}\right)$ = 5.23 x 107 Joules / kg = 14.76 kWh /kg

  To add orbital velocity energy at GEO, an additional 0.96 kWh / Kg is needed, 3.1 x 103 m/sec, for a total of 15.72 kWh per kg from the equator to GEO. At $0.10 per kWh electric rates, that is an added energy cost of only $1.58 per kg from ground to GEO. Any further expended transportation energy is overhead inefficiency, a function of the type of transportation system.
- This compares to the work done to mass by accelerating it to escape velocity, 17.8 kWh/kg. Emplacement in GEO is 91% up out of Earth's gravity well.

Estimating The Mass And Power For KESTS To GEO Transportation Systems

KESTS Crossection in cm^2	0.1	1	1000
KESTS total mass in kg	3.9E6	3.9E7	3.9E10
Power input to KESTS in kWh	6E4	6E5	6E8
Mass to GEO in kg per hour	1.8E3	1.8E4	1.8E7

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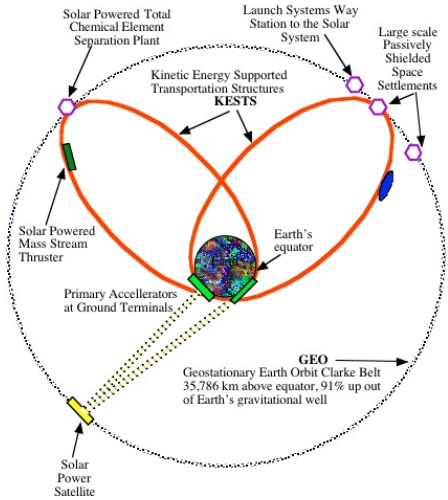


Why Do This?

Enormous New Things Become Possible:

•To emplace huge factories in GEO

•To worldwide emplace and maintain SSPS power stations in GEO

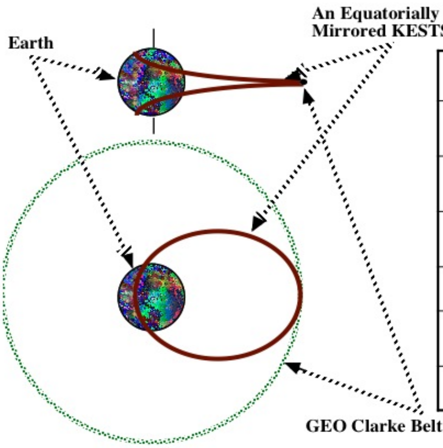
•To emplace total waste recycling plants into GEO and to transport recycle materials to/from them.

•To emplace GEO spaceport launch facilities and to lift spacecraft between ground and GEO

•To emplace first full-sized space settlements in GEO and move thousands of people and their goods up to live and work there in space

Potentials Made Possible By Utilizing This Technology for Creation Of KESTS To GEO

- Early construction of adequate quantities of Solar Satellite Power Stations from earth surface materials
- Construction of solar powered total recycling plants in GEO, and transport of toxic wastes to there for mass separation processing and then return down to earth
- Interplanetary exploratory and industrial spacecraft need only to connect to GEO, already 91% up out of the earth's gravity well, also far above the atmosphere
- Large scale passively shielded human habitation maintenance and tourist facilities can be built out of earth surface materials, easy commute to the ground



Northern Hemisphere	Southern Hemisphere	Longitude
Puerto Rico	Bolivia	68 °
Maine, USA	Comodoro, Argentina	70 °
North Africa	South Africa	20 °
China	Australia	120 °
Saudi Arabia	Madagascar	50 °
Japan	Australia	140 °

For more direct access far from the equator, perhaps KESTS can be built in pairs, balanced across the equator, leaning on each other where they meet in GEO. Bending stress needs to be absorbed mostly by stator strength of materials.

Benefits

- Enormous new business opportunities become available, by ensuring availability of abundant clean electrical energy worldwide for the future, and by rapidly embracing a space-based civilization:
  - – Ability to emplace many SSPS in the near future
    - At \$0.10/kWh, energy added to place in GEO is only \$1.74/kg
  - – Ability to profitably take full responsibility for total recycling of civilization's toxic waste materials of all kinds, and closing the industrial materials loop
    - Abundant zero-gee hard vacuum for large mass separator plants
  - – Enable interplanetary industrial spacecraft launches to be from GEO instead of from the ground
    - GEO is already 91% up out of the Earth's gravitational well

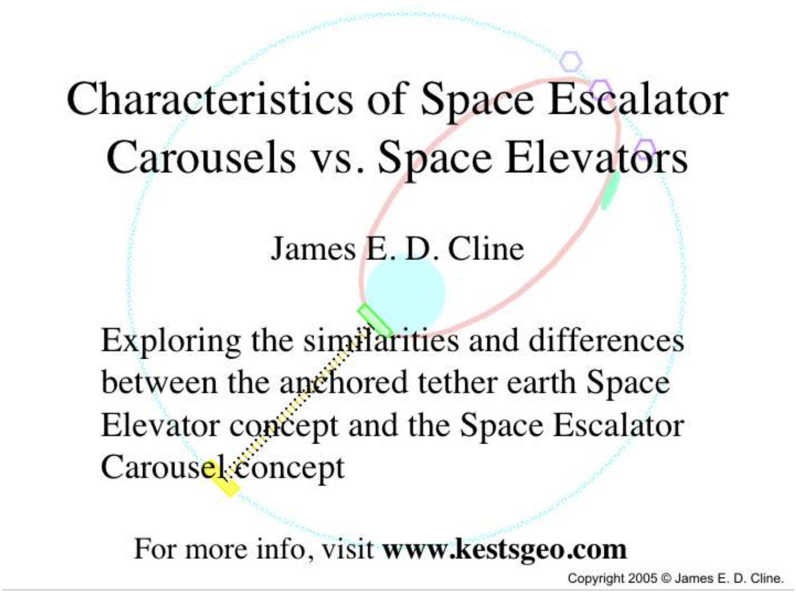
Summary

- A new field of transportation technology is proposed to be created
  - Involves the energy and momentum exchanges between electric motor moving armature segments and the motor's stationary stator maglev track
  - Armature segments slide along maglev tracks in a hard vacuum at km/s velocities
- This technology could be used in:
  - Electrical energy storage for power grid load leveling
  - Electrical power transfer across vast distances
  - Momentum-exchange delivery throughout very long and high transportation structures
  - Planet-encircling kinetic energy supported ground to space transportation structures, with wisdom, could open up the Earth's ecosystem to the vast resources of the solar system
- The enabled business opportunities are diverse and immense.

For more info, visit www.kestsgeo.com

Slides from *Characteristics of Space Escalator Carousels vs. Space Elevators*

One of the technical papers the author presented at the SESI Space Conference in 2005 was one titled "Characteristics of Space Escalator Carousels vs. Space Elevators" which compared the two basic forms of lifting structures capable of electrically lifting payload from ground up into GEO. The following are some of the presentation slides the author prepared for that paper.



Background

- The efforts to build transportation structures between ground and space, via anchored tether elevator and energy strengthened structures, have been parallel efforts to gain adequate access to space before resources become sufficiently limited to prevent further economical space access.
- Some of those dwindling resources involve loss of students interested in the sciences and engineering, lacking vision for use of technology to provide adequate clean energy for future needs worldwide, a sustainable ecosystem, room to grow, and interesting things to do in peaceful times.

Background

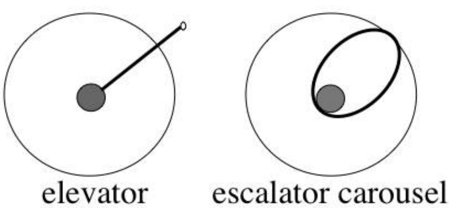
- Conventional launch vehicle access to high earth orbit is extraordinarily extravagantly wasteful of energy, a mere 15.7 KWh/Kg portion is all that is actually given to payload by lifting it from the ground at the equator up into GEO.
- Both the Space Elevator and the Space Escalator Carousel have the potential to bypass the extraordinary energy inefficiency of rocketry space access from the ground, in a time when energy is becoming very expensive, perhaps to crippling levels.

Both the space escalator carousel and the space tether elevator could fully enable commercial space access

- Electrically lifting spacecraft's payloads to high earth orbit could finally enable the 1960's concept of SSPS to be built there in GEO, and similarly an incredible array of other things of great usefulness to civilization would become possible.

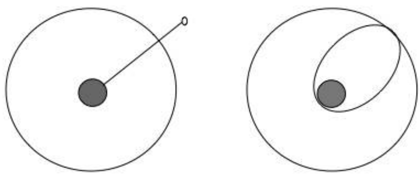
Overall shape comparisons between space escalator carousel vs elevator

- The space elevator's shape is linear, to out beyond GEO for counterweight balance, GEO connection is above ground terminal site.
- The space escalator carousel's shape is elliptical, encircling the planet, its GEO connection is above the opposite part of planet relative to ground terminal point.



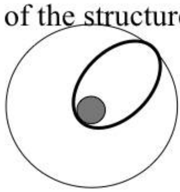
Supporting their huge structure's weight

- The space elevator utilizes the centrifugal force on counterweight mass out beyond GEO to balance the weight of anchored tether below GEO, thus extreme tensile strength to mass ratio tether material is needed.
- The space escalator carousel's weight is centrifugally supported by stored kinetic energy within the planet-encircling structure, thus requires only conventional strength materials.



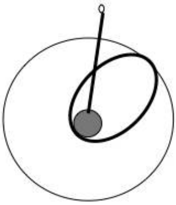
Supporting the carousel’s huge structure's weight

- The escalator carousel's shape being approximately that of an orbital transfer trajectory between earth equatorial surface, looping around the planet elliptically to reach GEO above the opposite side of the earth; the armature mass streams travel on inductive maglev tracks sufficiently faster than orbital velocity as to create outward centrifugal force somewhat greater than that needed to counterbalance the weight of the stationary part of the structure with its loads.



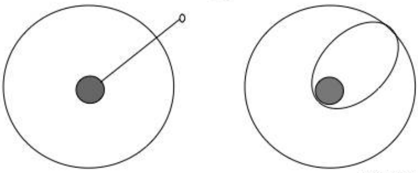
Simultaneous Use of both Kinds of Structures

- There may be potential for building both the carousel and tether structures, interconnecting them where they cross in space in the equatorial plane.
- This could enable multiple embarkation points with their options for connecting to conventional ground transportation systems, utilizing the best characteristics of each system to advantage.



Conclusions

- Early preparation of the basic design options for both elevator and escalator carousel, and their corresponding sets of technologies would give the future more options for comfortable growth, or maybe even survival of a large portion of civilization's people.
- Elevators need development of high power efficient laser systems and tether materials; Escalator Carousels need development of sliding armature energy-momentum transfer technology.



KESTS Technology Summary

Scenario

This adventure story plays out in an area formed by the surface of our planet Earth, its Low Earth Orbit, LEO; and Geostationary Earth Orbit, GEO. The final transportation structure that links the two, is called a "KESTS," which stands for "Kinetic Energy Supported Transportation Structure," also known as a "Space Escalator Carousel." Since this structure is intimately involved with the novel's playout, the basic principles of it are described below for those a bit more curious about this technology involved in the adventure.

Why use a KESTS Transportation Structure; and How Would It Work

The actual energy added to payload by having moved it from the ground up into GEO orbit is only 7.3 kilowatt-hours per pound mass lifted up into orbit there. That is about 73 cents per pound, at a rate of 10 cents per KWh of electrical energy.

Compare that with the current cost of over $10,000 per pound lifted into GEO, as needed by rocket launch vehicles, because they have to lift the weight of a huge amount of fuel for the trip and the tankage to hold all that fuel and the big engines to lift all that weight; but out of all that $10,000, only 73 cents of it actually gets applied to the payload put into GEO; which is the actual purpose of it all.

Lots of new kinds of great things can be done in GEO, as described more a few pages later here, at anywhere

near such low transportation cost of 73 cents per pound; along with sufficiently rapid payload throughput capacity to build the huge facilities up there and maintain them.

The KESTS to GEO transportation structure concept appears to have the potential to provide that function.

Considering our conditioning from watching the spectacular launches of the massive rockets now expensively needed to do even a little bit of putting things into GEO conventionally, probably the value of 73 cents of energy per pound seems way too low, for the energy that is given to payload mass put up into GEO from the ground. So, let's take a quick look at it.

First, we know the energy given has to be less than that given to a mass by giving it "escape velocity", the speed with which launched straight up it will never return. That is about 25,000 mph, 1.12e4 m/s. For a pound or 0.454 kg given this velocity, it takes
$E = 0.5MV^2$ = 2.836e7 Joules of kinetic energy which is equal to 7.878 KWh. At an electrical energy cost of 10 cents per KWh, that is 79 cents of energy given to the one pound mass in accelerating it so fast it will never come back (if there were no atmosphere to punch through, of course) and clearly to go into lower orbit it receives less energy than that; so this gives us a calculation check limit.

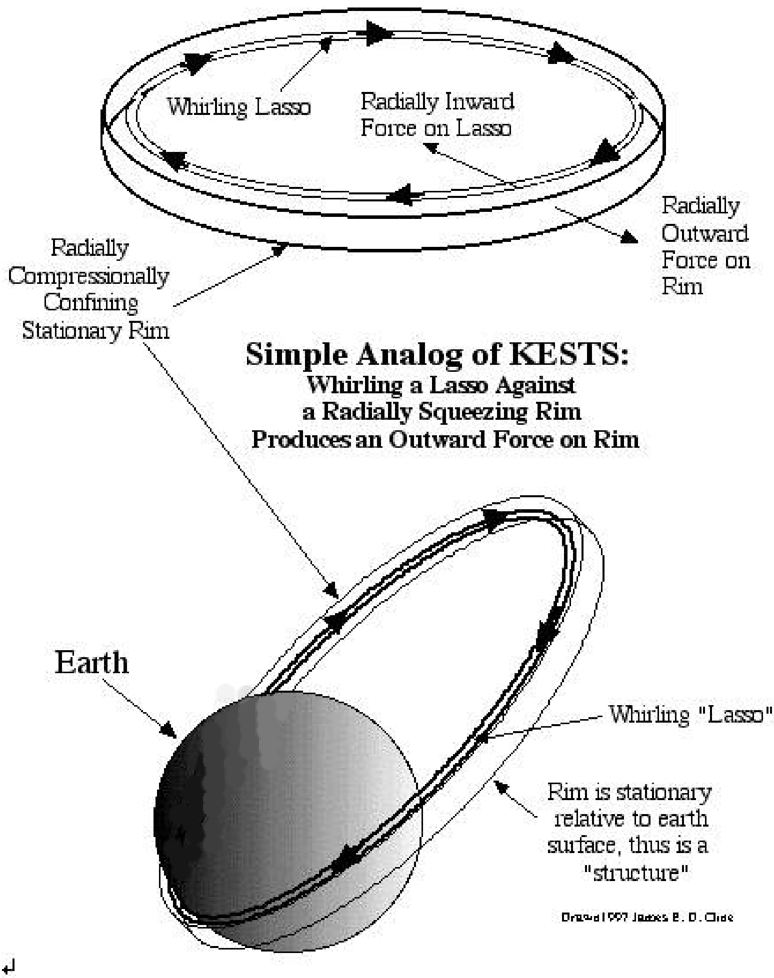
The energy needed to lift between two different altitudes in an inverse square gravitational field is
$E = GMm ((1/R_0) – (1/R_1))$ where R_0 is the radius of the lower altitude, 6.378e6 meters in Earth's case, and R_1 is the radius of Geostationary Earth Orbit 4.23e7 meters. That is 14.76 KWh per Kg or 6.71KWh per pound in the vertical lifting up to GEO altitude; then to give the mass an orbital velocity of 3.07 Km/s at that

altitude, again from $E = 0.5MV^2 = 2.14e6$ Joules = 0.594KWh; adding the two energies together = 7.3KWh per pound mass to move it from the ground up into GEO orbit.

Not to be confused with a KESTS, the more familiar “Space Elevator” is a linear anchored tether structure linking the ground with high earth orbital altitudes, is a different kind of way to do such things; but has its own unique set of characteristics that are not as well suited for the massive construction of facilities in GEO as envisioned here, even if there were a sufficiently strong construction material existing for the tether.

The KESTS bypasses that problem with the anchored tether Space Elevator, by instead supporting the weight of a transportation structure through kinetic energy stored within the structure and expressing as structurally distributed outward centrifugal force in opposition to the inward force of gravitational attraction on the mass of the structure and its live loads.

As used in this novel, the KESTS has a variety of potential forms; each having the common characteristics of being a transportation structure in the form of a hoop or band that eccentrically encircles the planet, which has its weight supported by the rapid rate in which its electric motor hoop armature spins along its path around the planet generating outward centrifugal force that balances the inward force of gravity on the overall structure; and also that payload is lifted between ground and orbit by means of electromagnetically braking against the upward-moving part of the armature mass, dragging the payload up to orbit, and similarly gently lowering it back to the ground, possibly returning



(Graphic from a paper titled “KINETIC ENERGY SUPPORTED ELECTRICALLY POWERED TRANSPORTATION STRUCTURES” which the author wrote and presented in May 1997 at the Space Studies Institute's space conference at Princeton, NJ, but was unfortunately rejected for publication at the time.)

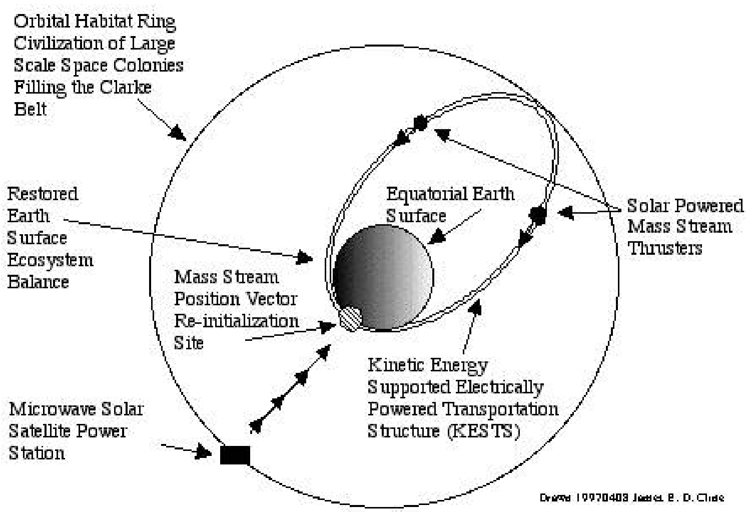
some of its energy back into the system when returning to the ground. This means that the captive spacecraft needs no big rocket engines nor lift heavy fuel for the trips between ground and GEO, enabling great energy efficiency. Again, the energy actually supplied to payload during the lifting is only 15.7 KWhr/kg,
7.3 KWhr per pound mass, about 73 cents of electricity per pound lifted up from the ground into GEO, when starting from somewhere on the equator. Again, compare with the energy given to mass by accelerating it to Earth's escape velocity of 25,000 miles per hour, as launched from the ground if there were no impeding atmosphere; this is 7.9 KWh per pound, and clearly would be somewhat more than is needed to lift merely up into GEO.

The preceding diagram shows the outward centrifugal force on a spinning hoop; and then an elongated version spinning around the earth in the equatorial plane along the approximate path of an Orbital Transfer Trajectory between ground and GEO, the spinning's outward centrifugal force balancing the inward gravitational force on the non-spinning part of the hoop.

A special case of the KESTS is the “Circular KESTS” which spins around the planet in a circular shape, and needs to have access up to it by other means, but once up there, can cruise along at the altitude of the KESTS supported by its above-orbital-velocity constrained path centrifugal force as it goes around the planet. Solid versions of KESTS may be possible too, simpler in design, but of lesser utility than the discontinuous armature mass stream technique mostly used in these descriptions as explored in these fictional adventures.

It is basically a gigantic perimeter synchronous electric motor, built in the general shape of an ellipse that extends around the earth; connecting between the

earth surface and GEO. The KESTS internally has high velocity armature mass streams which continuously travel around the ellipse, riding along magnetic levitation tracks at several times orbital velocity, so that their aggregate outward centrifugal force balances the earthward inward force of gravity on the non-moving part of the ellipse; which is attached to the earth surface at the contact point roughly where an Orbital Transfer Trajectory ellipse would graze the Earth's surface, if there were no atmosphere.



KESTS to an Orbital Habitat Ring
Infilling the Clarke Belt

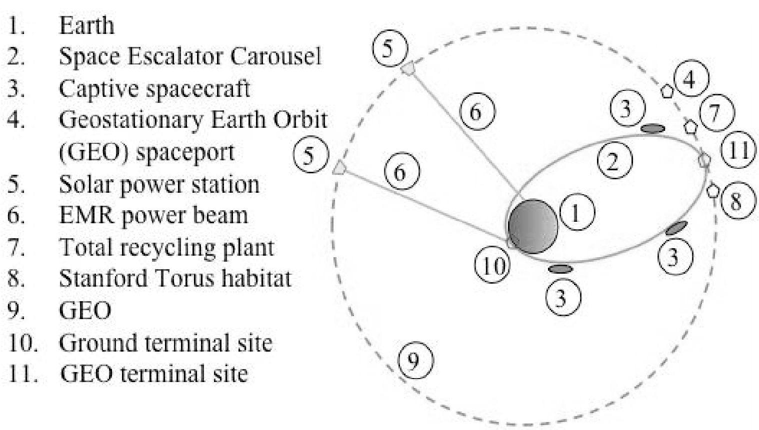
(Graphic from a paper which the author presented in May 1997 at the Space Studies Institute's space conference at Princeton, NJ, but it was rejected for publication at the time)

In this novel, the structural attachment to the earth's surface is primarily within a tunnel in Cayembe Peak in

the Ecuadorean Andes Mountains on the earth's equator. The earth-stationary part of the KESTS includes the tubing that keeps a hard vacuum environment for the armature segments to flow within while traveling within the earth's atmosphere; and also holds a second type of magnetic levitation track on its outside, along which captive spacecraft are lifted up to space by electrodynamicly dragging on the upward-bound armature mass streams until they reach GEO.

Functions of Major Facilities Enabled Built in GEO by Use of KESTS Technology

The following is a diagram showing the KESTS Space Escalator Carousel, showing the Earth in the center, and the Geostationary Earth Orbital ringing it; and some of the major kinds of infrastructure that the KESTS could enable be built and maintained in high earth orbit, as is involved in this novel.



(Graphic from the author's presentation slides used in presenting the technical paper “The Space Escalator Carousel's Unique Potentials” Space Exploration 2005 Conference Proceedings, SESI, 2005, 230-238 at the Space Exploration 2005 conference in Albuquerque, NM in 2005.)

Solar Power Satellites have been proposed for the past four decades to provide abundant clean electrical power to all the nations of the earth, but there has been no economical means to lift construction materials to build them up there in space, if limited to conventional, rocket propelled launch vehicle means to reach space. The KESTS would finally enable those Solar Power Satellites to be built and maintained up in high earth orbit, GEO. The electrical energy to run the KESTS itself would be beamed down from a Solar Power Satellite in GEO, to the accelerator site on the ground in the mountain tunnel in Ecuador.

The Total Recycling Plant is a second primary kind of facility that probably could be economically built and operated in GEO as enabled by KESTS transportation. These would be gigantic basic mass spectrometer type devices built in the free-fall hard-vacuum GEO environment, that would use solar energy to totally convert toxic and otherwise environmentally-dangerous industrial byproduct material as well as worn out electronics materials and nuclear wastes, back into their basic elemental states. The incoming waste material would be vaporized into a plasma state by focused solar energy; then using electrostatic fields to be separated into positive and negative ions, and accelerated down a pathway to uniform exit speed as they launch across a magnetic field, and the ion's trajectories are bent according to their unique mass-charge ratio, there to be collected in containers placed out around the magnet at the appropriate angles to where the ions were bent by the magnetic field. When the containers are filled, the materials would be utilized for manufacturing up there in GEO, or be returned down the KESTS for industrial re-use in their now pure form; or perhaps in the case of some dangerous radioactive isotopes, being launched into the Sun.

High Spaceports in GEO would be for conventional rocket facilities. Since GEO, already 91% up out of the Earth's planetary gravitational energy well, they would be extremely energy efficient terminals for spacecraft to travel to and from other destinations in the solar system, including the Moon, Mars, and the moons of the other planets. Starting as cheaply lifted electrically up the KESTS from the ground up into GEO, the spacecraft would have their assembly completed at the spaceports; fueled with fuel brought up the KESTS; and readied for their duties as very large scale manned space exploration expeditions, or for freighting of industrial materials from the Moon and other sources such as asteroids.

The 1 or 2 mile diameter wheel type of city built in space is the last major type of facility involved in this story, much like was envisioned as the 10,000-person space settlement originally designed in 1975 under NASA sponsorship at Stanford, for construction and use in the Earth-Moon Lagrange-5 (L-5) location in space; but adapted here for use in GEO; initial construction from materials brought up the KESTS from the ground, including the water and sawdust for use in making the passive ice shields out of water ice instead of from lunar materials; the water ice would be a benign addition to the earth's atmosphere if and when eons later, the ice shields would be returned to the earth via atmospheric entry.

In the ongoing saga of this novel series, this KESTS to GEO structure was originally built to enable the construction of Solar Power Satellites in GEO to power the Earth surface civilization with abundant clean electric power; but by the time KESTS was approved to be built, the whole Earth's ecosystem was clearly in collapse mode; so the plan was made to move the Earth's population temporarily off-planet into cities built

fully around the planet in GEO, while the ecosystem was being jump-started back to long term sustainability. Each city being similar to the wheel-shaped space designs of the mid-1970's which would be nearly self-sustaining cities of 10,000 people each; and would be passively shielded by water ice that was reinforced by sawdust, and its outside covered by a thin film of aluminum foil to reflect the sun's energy.